RAILWAY ENGINEERING

AND MAINTENANCE OF WAY.

BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK

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The Panama Railroad And Its Relation to the Panama Canal*

Ralph Budd.

At intervals since the discovery of the Pacific ocean by Balboa in 1513, the improvement of transportation facilities across the isthmus of Panama has attracted the attention of various nations and capitalists. The first move was the opening of a trail about the middle of the sixteenth century by Spain. It ran from Porto Bello, an old fort about fifteen miles down the coast from Colon, to the old city of Panama. A little later this route was improved upon by using the Chagres river from its mouth at Fort Lorenzo, about ten miles up the coast from Colon, to Cruces, and from Cruces to Panama city by trail. This latter route continued popular until the completion of the Panama railroad in 1855, and was used by the gold seekers en route to California in the early 50's. The completion of the Panama canal remains to afford unobstructed trans-isthmian traffic facilities.

The Panama Railroad Company was organized in 1850. Construction work began the same year and the road was completed and put in operation in 1855. The difficulties overcome by the early engineer parties were almost insurmountable; in addition to the inevitable difficulties incident to the unhealthy tropical climate and the dense jungles, every possible obstacle was placed in their way by the owners of the pack-trains and the fleets of cargoes who had, with the rush of the gold seekers to California, built up a very lucrative business. The fact that the line as built lies directly on the route, and in many places within the prism of the Panama canal, as located after the completion of extensive surveys and the preparation of complete contour maps, speaks for the character of the original railroad location work. The railroad as first built had a very narrow road-bed both in embankment and excavation. It was originally built with softwood ties from southern United States. The torrential rains soon necessitated the improvement of the road-bed by widening cuts and fills and by ballasting, and the short life of ordinary timber led to the use of lignum vitae ties. The road was built 5 ft. gage and has always been so maintained, all of the tracks on the isthmus, both Panama railroad and Isthmian Canal Commission, now being of this gage.

During French canal times—1881 to 1904—the Panama railroad was controlled by the French canal company, but the road has been practically always managed by Americans. It has always been prosperous and always well enough maintained safely and expeditiously to handle its business.

The whole organization of the Panama Railroad Company is subsidiary to the Isthmian Canal Commission, and its chief business is in facilitating canal construction. The chairman and chief engineer of the Isthmian Canal Commission, is also president of the railroad company, while the commissioners are members of the railroad company's board of directors. The general manager of the railroad, who has charge of operation and construction work, also has the title of assistant to the president and reports directly to him.

Rebuilding the Old Railroad.

The road is 47.7 miles long. On the advent of the Isthmian Canal Commission in 1904, it was handling a freight traffic of 17,000,000 ton miles annually. It was early decided to use the railroad to haul away the excavated material from the Culebra cut, as ample space was found on low ground along the railroad where dumps could be developed quickly and cheaply without the necessity of building separate tracks to reach them. This use of the railroad, and the shipments of all the material and supplies incident to work on the canal, increased the tonnage in the years 1906-7 to 42,000,000 ton miles; during 1907-8 to 150,000,000, and in 1908-09 to 280,000,000, probably the maximum, as the Culebra cut proper is being shortened by completion of the canal near its ends, and the development of large new dumping ground along the re-located line of the railroad will tend to decrease the tonnage hauled over the present operated line.

To prepare for the great increase in traffic, the railroad has been almost entirely rebuilt, and 37 miles of it was double tracked. The work of rebuilding and double tracking was practically completed at the end of the fiscal year 1907. The portion double tracked is mostly built on embankment, so that the grading for double track was an unusually simple and economical proposition; namely, that of unloading dirt trains from the Culebra cut along the main line and widening the fills thus built sufficiently to carry another track. There were a few cuts, the larger of which had to be taken out with steam shovels. In order to avoid delay to the shovel and interruption to traffic that could not be eliminated from steam shovel work, small pan cars (old French Decauville cars) of about 1-3 cu. yd. capacity were used in all cases where the material could be disposed of within reasonable distance. Some of the smaller cuts were taken out by hand-work with wheelbarrows. For the most part, however, the work of double tracking consisted of widening the original embankments sufficiently to support a new track, then moving the new tracks over to 13 ft. centers by unloading filling from it and keeping it thrown over to the edge of the bank. The equipment used consisted of Western dump cars and flat cars unloaded by side plow Lidgerwood unloader. Both McCann and Jordan spreaders were used for leveling the fills. In locating the second track it was shifted from one side to the other of the old main line at many places to better the alignment, to save cutting, or to improve the vision for safety of operation. In some places great improvements could be made by surprisingly small effort. An instance of this is between Juan Grande and Gorgona, (Fig. 1) where 731 ft. of distance, 104 deg. 34 min. of curvature and 4 ft. of rise and fall were eliminated by building 3,300 ft. of line across a valley which was filled by dumping excavated material from the canal. There were practically no sidetracks on the old line prior to the Isthmian Canal Commission days, few being needed. A timetable as of June, 1904, shows ten house tracks, five of which were spurs, and four passing tracks, the total length of

*Presented before the Western Society of Engineers.

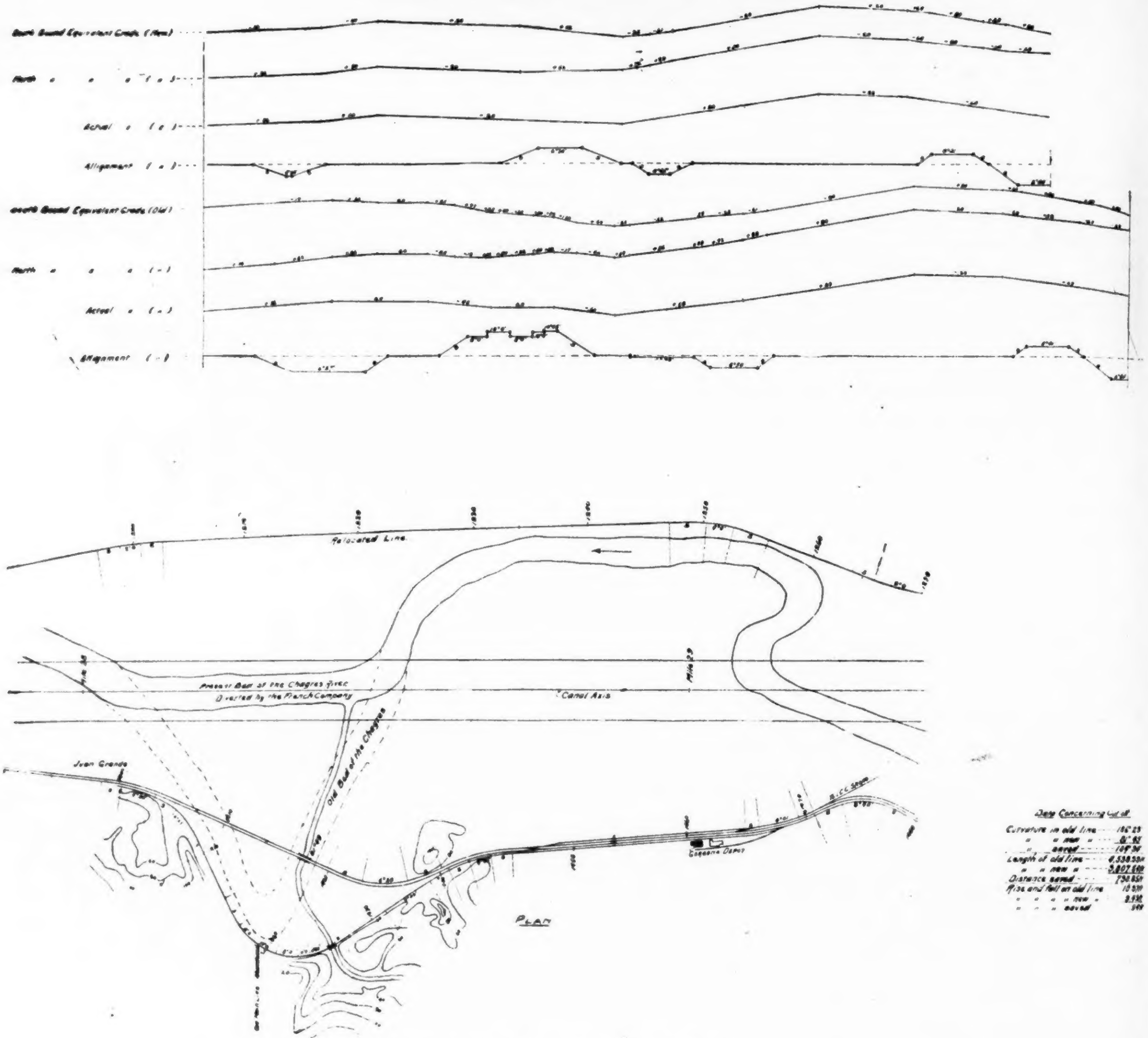


Fig. 1.—Line Revision, Panama R. R.

house and passing tracks being a little less than 10,000 ft. Sixteen house and commissary tracks have been built, having a total length of 17,100 ft., and eight passing sidings having a total length of 12,300 ft. In addition, 64,500 ft. of yard tracks were built at Cristobal and La Boca (now called Balboa). The old stations were of shed type 16 ft. wide and 80 to 100 ft. long, one end being enclosed for agent's and operators' office, and the other for freight; the middle portion served as a shelter for passengers. These stations were altogether inadequate for the requirements. Twelve new passenger and freight stations were built at the most important places and five were remodeled.

The Culebra station is shown in Fig. 2, and is typical of those which were newly built. These are frame buildings with corrugated iron roofs, and are 30 to 126 ft., the passenger, office, and freight sections being 30, 20, and 76 ft. respectively. The passenger room is not enclosed, as will be noticed in the view. Five-room living quarters are provided in the second story for the agent.

During 1906-7 all tracks were laid with 70 lb. Bessemer steel rails, which replaced the 56 and 60 lb. rails in use on the old road. On the eleven-mile section from Las Cascadas to Tabernilla, where the traffic is most dense, the 70 lb. rail was replaced with 90 lb. Bessemer steel rail in January, 1908. On all of the curves in this section the 90 lb. Bessemer rail has been replaced with 90 lb. open hearth steel rail of carbon content 0.70 per cent to 0.80 per cent, and phosphorus 0.03 per cent to 0.05 per cent. This rail is giving much better service than the Bessemer, but it has been in the track only since April 25, 1909, so full comparisons cannot as yet be made.

Data in reference to rail wear on an 11 degree curve is given in Fig. 3. Manganese steel frogs are used in turnouts leading to and from the canal where traffic is most dense. They have proved very satisfactory and indicate a life of five or six years where Bessemer steel, spring rail frogs had to be changed every four months. One regrettable thing in preparing the Panama railroad for handling the Canal Commission traffic and maintaining it under this traffic was the necessity of replacing the lignum vitae ties in the old track with cypress ties. These old ties had been in the track from ten to thirty years, and many of them were as sound when removed as when first laid, but they were all pole ties having a face of from 6½ to 7 inches, and were from 7 ft. to 7 ft. 9 in. long. They presented such small bearing surface that it was impossible to maintain the track under the traffic that was imposed. Use has been made of them in house tracks and yard tracks, and as fence posts; of late they are also being used by the Isthmian Canal Commission in making steam shovel jack blocks.

The maximum train load on the isthmus consists of two 120-

RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

Fig. 2.—Culebra Station. Type Used on Old Line, Panama R. R.

ton locomotives followed by a trainload of 4,400 lb. per lineal foot. All bridges on second main track were built for "Cooper's E-50" loading, and all of the bridges on the old track were strengthened accordingly. Pile bridges were used on the second track throughout. In order to avoid interruptions to traffic a pile driver was spurred on the widened embankment. Where the bridges were very short, however, the piles were driven from the machine standing on the old line. There are 65 bridges in all; from 12 to 150 ft. in length. Practically all were too light to carry the new cars and locomotives. Most of them were iron or steel spans, ranging from 50 ft. down, and were easily and cheaply strengthened by driving pile bents under them to shorten the span. A notable exception was the bridge across the Chagres river at San Pablo, known as the Barbacoas bridge. This consisted of six wrought iron through plate girder spans from 101 to 109 ft. long. Instead of double tracking this bridge, a gauntlet track was laid across it, using No. 12 frogs. The north three spans of this bridge are over the river channel, and it was therefore impracticable to put supports under the middle of these spans on account of the drift-wood during the

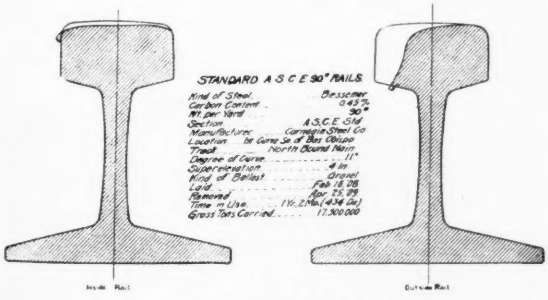


Fig. 3.—Wear of Rail.

rainy season. Three new spans were therefore put in place of those, and a new floor system put in the three old spans, which were then supported by steel bents placed under the middle of each of them. The new girders were put in at the beginning of the rainy season, when falsework could not be held in the channel except immediately on the down-stream end of the piers, and built as extensions to them. The new spans were therefore installed in the following manner: A span complete, including the deck, was loaded on flat cars and set immediately over the place where it was to be installed. The new span was then blocked up on the old girders and the flat cars taken away. A 75 ton steam wrecking car was brought up against each end of the new span, and the span lifted bodily and held suspended in the air, while the entire old span was pulled down stream onto the falsework. This was accomplished by two Lidgerwood unloaders, which stood on the track at the end of the bridge, and each of which handled one end of the old span. After the old span was removed, the new one was lowered into place by the wreckers. The entire operation consumed about four hours for each span placed. The work was done on three consecutive Sundays. In Fig. 4 is shown the second span being placed. The total weight of the span, complete, when handled by the wreckers, was 115 tons. Fig. 5 shows a plan and section of the old wrought iron girders. These girders were installed about 1870; the exact date is not known.

The majority of the loaded dirt cars handled over the Panama railroad tracks are what are called "Lidgerwood Flats." They are flat cars with a 3 ft. sideboard on one side, and with a 12 in. extension of the car floor on the other. When heavily loaded, as they usually are, the center of gravity is about 15 in. from the center of the track, and about two-thirds of the weight is on one side of the car. This creates a very peculiar condition for track maintenance. In order to avoid derailment of these loaded cars it is necessary to adopt 3½ in. as the maximum super-elevation for the outer rail on curves, regardless of the degree of curvature. With this super-elevation very few derailments occur, but with all other track conditions practically perfect and 6 in. super-elevation on an 11 degree curve, five derailments have taken place at the same spot in one day.

Fig. 4.—Replacing 109 Ft. Girder Span, Barbacos, with Steam Wrecker.

This unusual number was due to the fact that, early in the day, a loaded train with the heavy side of the car over the low rail, was flagged on the curve, and in slowing down became derailed, due to the decrease of centrifugal force, which would have prevented derailment at the higher speed. While no damage was done to the track by this train, the train crew reported the derailment and a slow order was placed, with the result that within the next few hours and before the cause of the trouble was discovered, four cars in other trains, especially badly loaded, were derailed in a similar manner. Reduction in super-elevation from 6 to 3½ in. prevented further trouble, although all trains run slow during the next twenty-four hours while damaged ties were being replaced.

The Relocated Line.

In general, the Panama railroad was built from Colon to Gatun, a distance of seven miles across a salt marsh. Here it reached the Chagres river and followed the Chagres valley, keeping more or less closely to the river for a distance of twenty-four miles to a point near Bas Obispo, where the Chagres makes a decided turn to run parallel with the continental divide, while the railroad keeps its general direction following the Camacho river up very nearly to the summit at Culebra, and then, after crossing the divide, it descends the Pacific slope in the Rio Grande valley. The Atlantic slope from Colon to Bas Obispo is quite flat, the elevation reached at the latter point being 85 ft. above the sea. Since the water in Gatun lake will

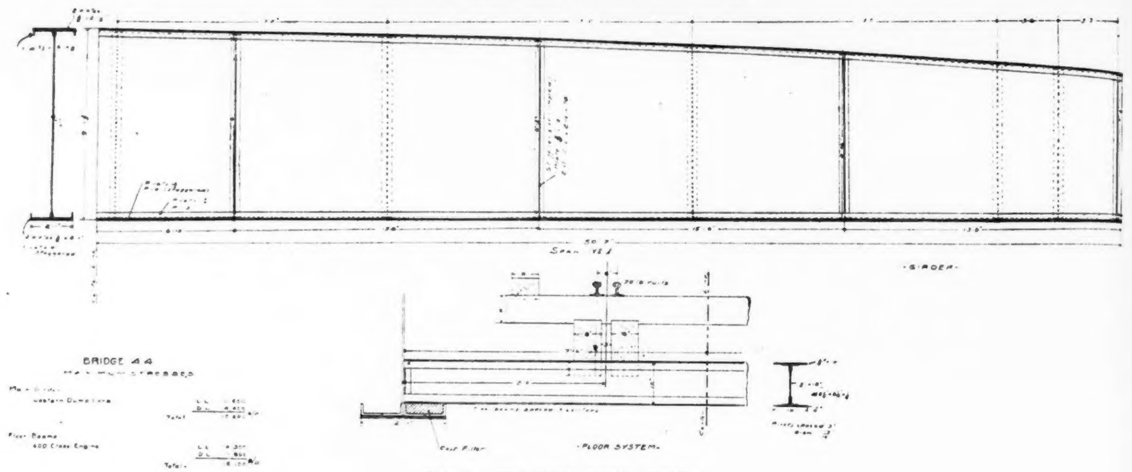


Fig. 5.—Old Plate Girder Bridge.

be normally at that elevation, it is apparent that all of the present line between Gatun and Bas Obispo will be submerged when the lake is formed. Similarly the lake will submerge the section of track from Miraflores to Paraiso on the Pacific side. Moreover, the railroad now crosses the canal in two places—once at San Pablo, and again at Paraiso. The section from Colon to San Pablo—23 miles long—lies on the east side of the canal; the middle section—San Pablo to Paraiso, 17 miles long—lies on the west side, and the southerly section from Paraiso to Panama—7 miles—is again on the east side.

These conditions necessitate the construction of a new railroad to take the place of the old one from Gatun to Miraflores. The minimum elevation of sub-grade for this new railroad through Gatun lake (Gatun to Pedro Miguel) has been fixed at 92 ft. above sea level, except at points opposite Gatun and Pedro Miguel, where the sub-grade is 95 ft. As the present line between Colon and Gatun, and also between Panama and Pedro Miguel lies only a few feet above sea level, it is necessary to begin the relocation at sufficient distance north of Gatun and south of Pedro Miguel to attain an elevation of 95 ft. on reaching these points. On the north end the new line joins the old at Mindi—2½ miles north from Gatun—and on the south end the junction is at Corozal—4 miles south of Pedro Miguel—a greater distance being used on the Pacific end because there are two sets of locks—one at Pedro Miguel and one at Miraflores—making an intermediate lake at an elevation of 55 ft. just south of Pedro Miguel. The entire length of the relocated line from Mindi to Corozal is 40 miles.

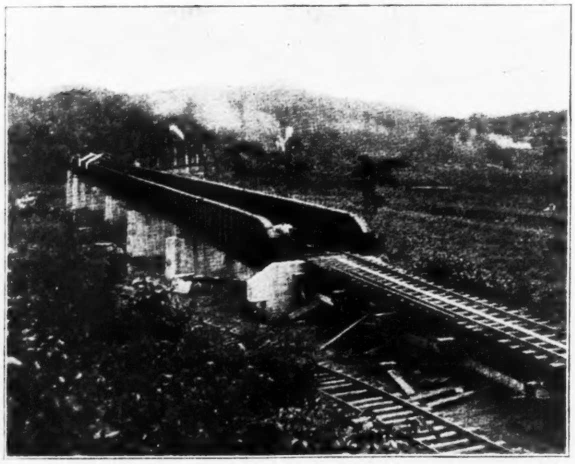


Fig. 6.—Gamboa Bridge.

Location parties were put into the field in September, 1906, under the direction of the assistant chief engineer of the Isthmian Canal Commission. The location was completed in March, 1907, and the right of way was practically all cleared by the end of April.

From Mindi to Gatun the line lies along a chain of hills which affords support to gain the necessary elevation at Gatun. From Gatun to Bas Obispo the line was located along the east side of Gatun lake. From Bas Obispo to Pedro Miguel it will occupy a 40-ft. berme left in the east slope of the canal at an elevation of 95 ft. above sea level. From Pedro Miguel to Corozal it crosses two deep valleys and passes through the Miraflores ridge in a tunnel; the fills across these two valleys were made of waste material from Culebra cut.

On May 23, 1907, the construction of the relocated line was turned over to the Panama railroad under the direction of the general manager. During the fiscal year of 1907-8 work was confined to three districts where the construction of the new line would materially aid the canal commission plans. These three districts were as follows:

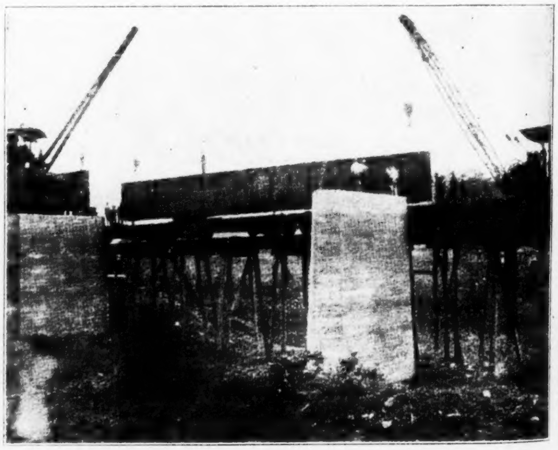


Fig. 7.—Placing Girder with Locomotive Crane.

First, work in the vicinity of Gatun in order to abandon the old railroad tracks which occupy a portion of the site of Gatun dam.

Second, construction of Gamboa bridge and three miles of track to open up dumping grounds.

Third, construction of two large culverts near Miraflores to admit of enlargement of dumps, and the construction of Miraflores tunnel.

The work in the first mentioned section consisted of build-

ing the new line from Mindi to Gatun and building a temporary track from Gatun to join the old line at Tiger hill, two miles south of Gatun. The temporary line crossed the Gatun river

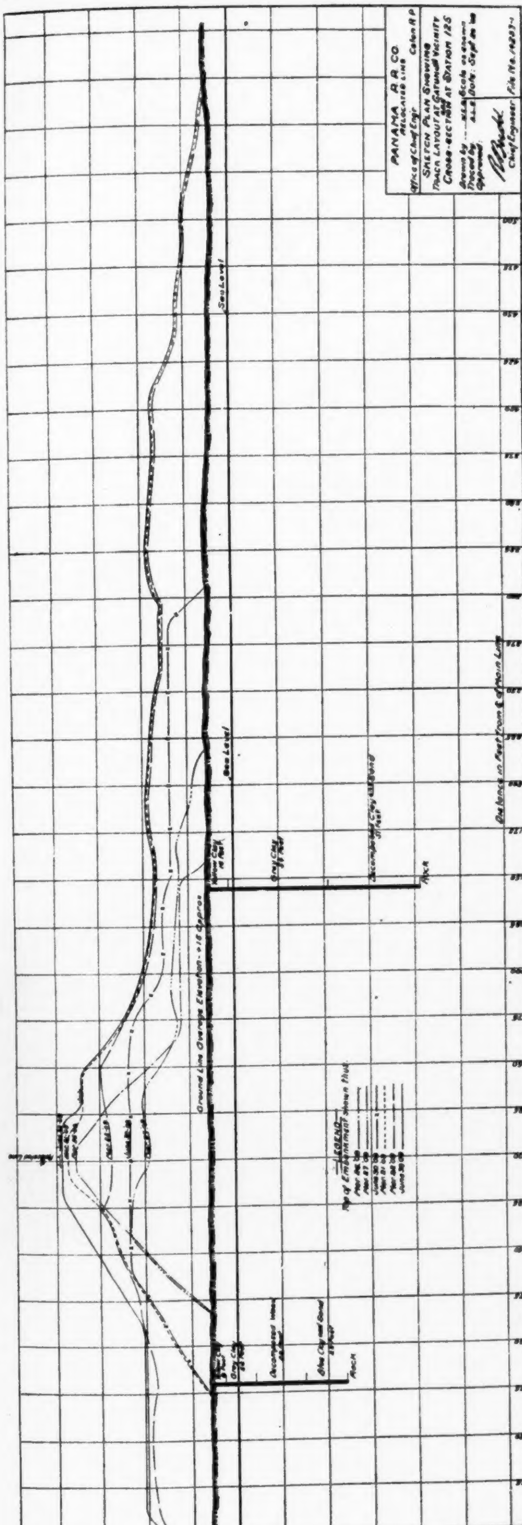


FIG. 9. EMBANKMENT, SOUTH OF GATUN—ON SOFT GROUND.

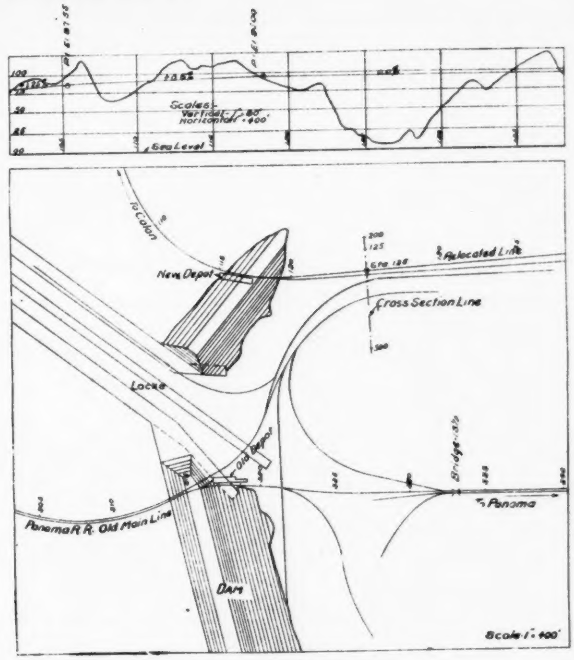


FIG. 9A.

Fig. 10.—Slide in Gatun Fill.

Fig. 11.—Embankment, Gatun, Before Slide.

and its wide, low valley, and was so located that the permanent embankment, when built, would include the temporary fill within its prism.

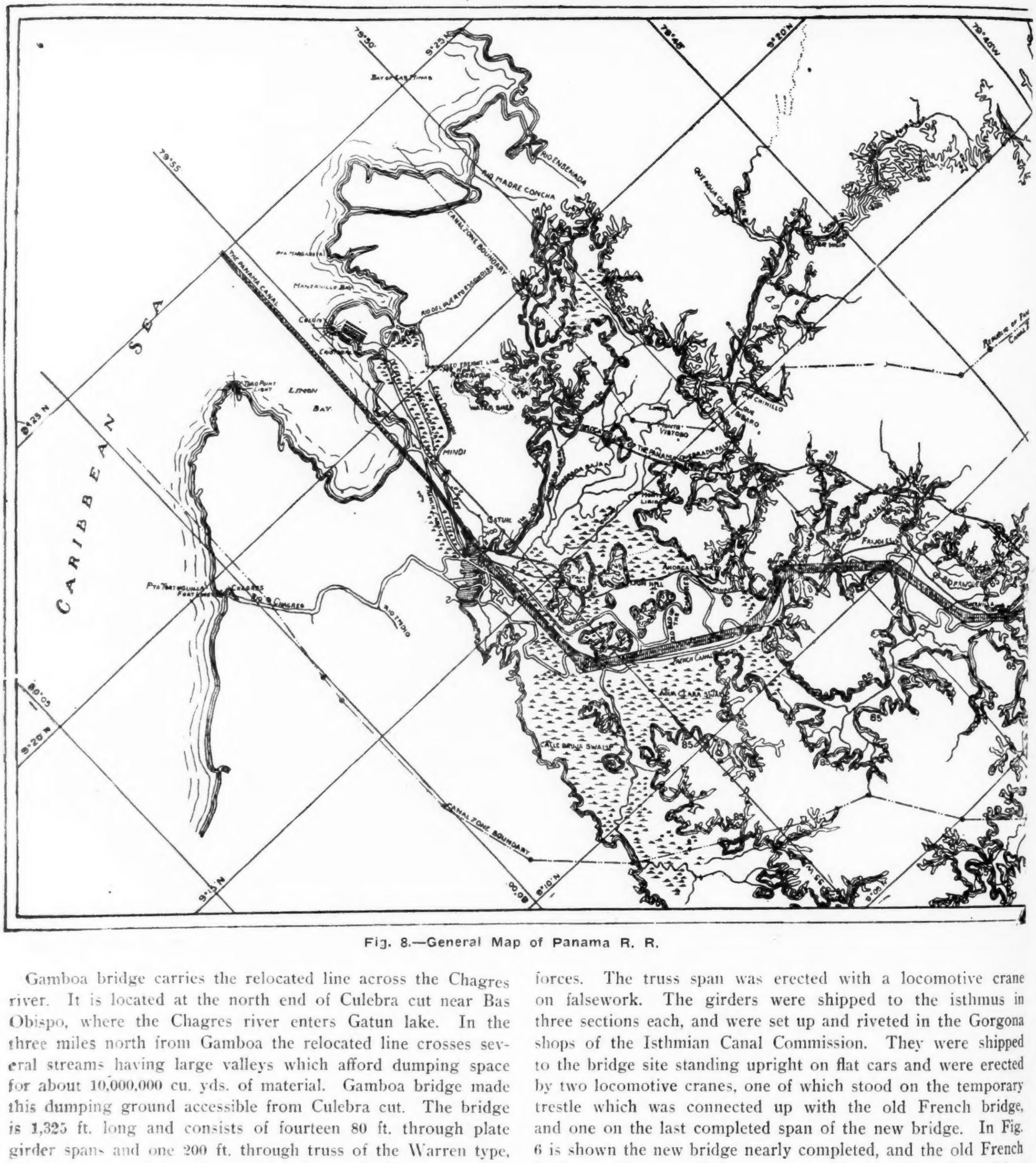


Fig. 8.—General Map of Panama R. R.

Gamboa bridge carries the relocated line across the Chagres river. It is located at the north end of Culebra cut near Bas Obispo, where the Chagres river enters Gatun lake. In the three miles north from Gamboa the relocated line crosses several streams having large valleys which afford dumping space for about 10,000,000 cu. yds. of material. Gamboa bridge made this dumping ground accessible from Culebra cut. The bridge is 1,325 ft. long and consists of fourteen 80 ft. through plate girder spans and one 200 ft. through truss of the Warren type, all resting on reinforced concrete piers and abutments. The bridge is built for "Cooper's E-50" loading and under the 1906 specifications of the American Railway Engineering and Maintenance of Way Association. The top of rail elevation is 99 ft. and the lowest member of the bridge is 93½ ft., that is 8½ ft. above the level of Gatun lake. The French canal company had built a bridge at this place, of which two truss spans, respectively 100 and 200 ft. long, were still standing. Although too light for heavy traffic, they were valuable for construction work. A temporary trestle was built from the north end of this old bridge, 18 ft. centers, from the new bridge to a point beyond the north abutment. The south end of the old bridge was connected by tracks with the tracks in Bas Obispo cut; over this track and bridge, all material for construction of the piers was handled, and the trestle served in place of falsework for the girder spans. All erection was done by the railroad company's forces. The truss span was erected with a locomotive crane on falsework. The girders were shipped to the isthmus in three sections each, and were set up and riveted in the Gorgona shops of the Isthmian Canal Commission. They were shipped to the bridge site standing upright on flat cars and were erected by two locomotive cranes, one of which stood on the temporary trestle which was connected up with the old French bridge, and one on the last completed span of the new bridge. In Fig. 6 is shown the new bridge nearly completed, and the old French bridge and trestle which was connected up and used for falsework, while Fig. 7 shows the two locomotive cranes placing a girder.

The two 20 ft. by 24 ft. reinforced concrete arch culverts were built between Pedro Miguel and Miraflores to carry the Pedro Miguel and Caimetillo rivers respectively. The construction of these culverts allowed the development of dump grounds in the river valleys, and gave access to the north end of Miraflores tunnel, work on which was also carried forward during the fiscal year 1907-8. During the fiscal year 1908-9 construction work was carried on over the entire line, and continuation of the progress now being made will see the track connected up throughout by April 1, 1910, except that portion which lies in Culebra cut proper.

While building a temporary line around Gatun dam, investigations were made to determine the character of the under-

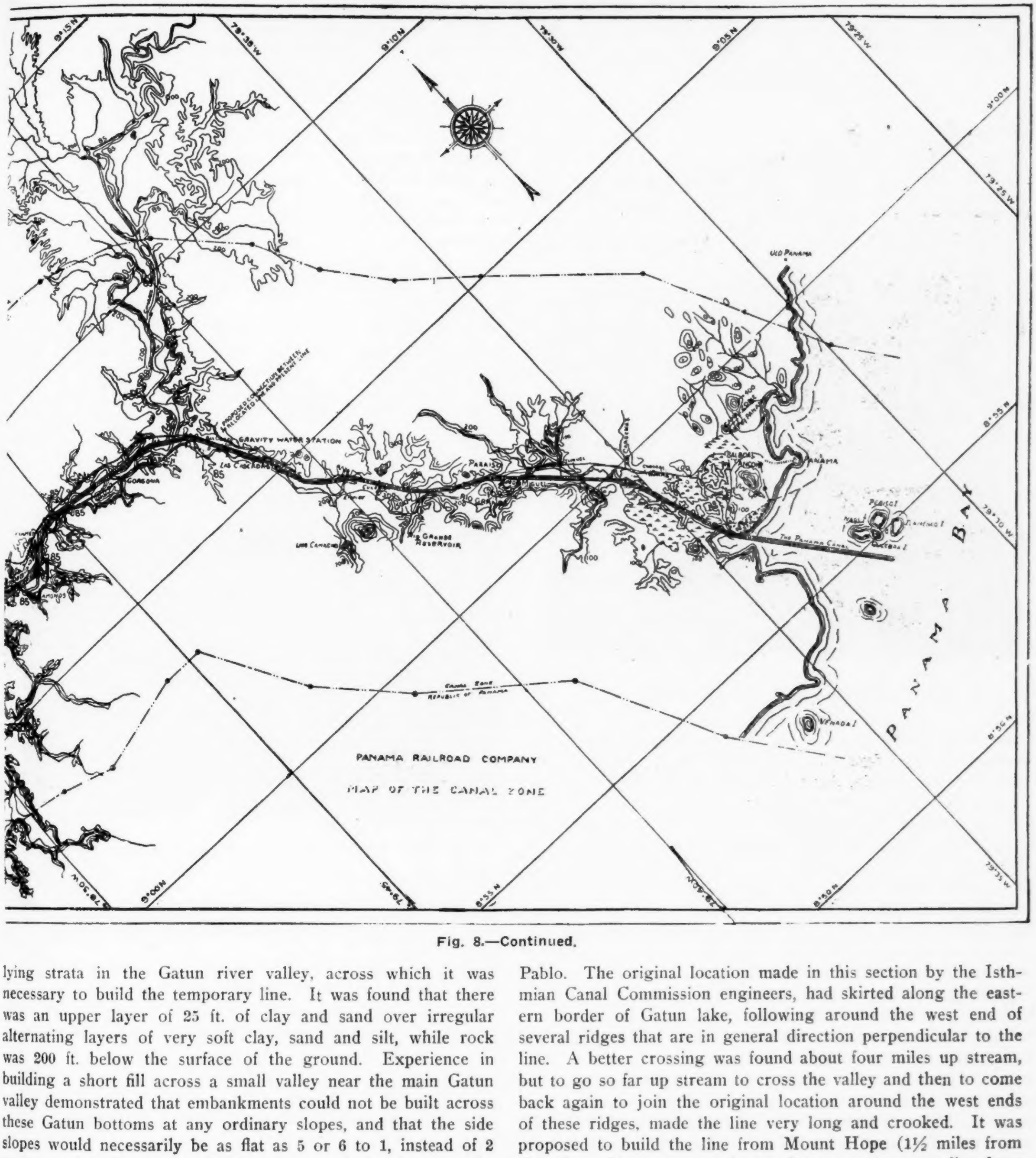


Fig. 8.—Continued.

lying strata in the Gatun river valley, across which it was necessary to build the temporary line. It was found that there was an upper layer of 25 ft. of clay and sand over irregular alternating layers of very soft clay, sand and silt, while rock was 200 ft. below the surface of the ground. Experience in building a short fill across a small valley near the main Gatun valley demonstrated that embankments could not be built across these Gatun bottoms at any ordinary slopes, and that the side slopes would necessarily be as flat as 5 or 6 to 1, instead of 2 to 1 as originally contemplated and as used elsewhere on the line. The valley in question is 6,500 ft. long, and the surface of the ground is 8 ft. above sea level. To build an embankment with subgrade at 92 ft. above the sea, with a top width of 40 ft. and side slopes 2 to 1, as originally contemplated, would have required 4,200,000 cu. yds. of material. To build this embankment at the same height and of the same top width, but with side slopes 5 to 1, would a little more than double the embankment quantities, requiring practically 9,000,000 cu. yd. of fill. Investigations were begun, looking to the abandonment of this enormous embankment. The construction of a steel viaduct was considered, but the idea was abandoned on account of the expense of maintaining it, as 76 ft. of the towers would have been submerged by Gatun lake.

In February, 1908, parties were put into the field to seek a new location further up the Gatun valley. No construction work had at this time been started between Gatun and San Pablo. The original location made in this section by the Isthmian Canal Commission engineers, had skirted along the eastern border of Gatun lake, following around the west end of several ridges that are in general direction perpendicular to the line. A better crossing was found about four miles up stream, but to go so far up stream to cross the valley and then to come back again to join the original location around the west ends of these ridges, made the line very long and crooked. It was proposed to build the line from Mount Hope (1½ miles from Colon) to this upper crossing, and to operate a spur line from Mount Hope to Gatun (5½ miles), but this was abandoned because it was desired to have Gatun and its permanent activities on the main line. The desirable thing to do, then, since it was necessary to go so far eastward to improve the bottom, was to keep the line back from the east border of Gatun lake and to cross the ridges instead of passing around to the west of them, and then to join the original location at a point about two miles south of Bohio, where the border of the lake and the original location turn back eastward on account of the topography of the country. This would not introduce any considerable distance, since it would place the line on the north and east sides of a quadrilateral, along the west and south sides of which the original location was made.

The ordinary reconnaissance in this country is practically impossible, but contour maps, showing 10 ft. contours below elevation 90, completed about this time by the Isthmian Canal

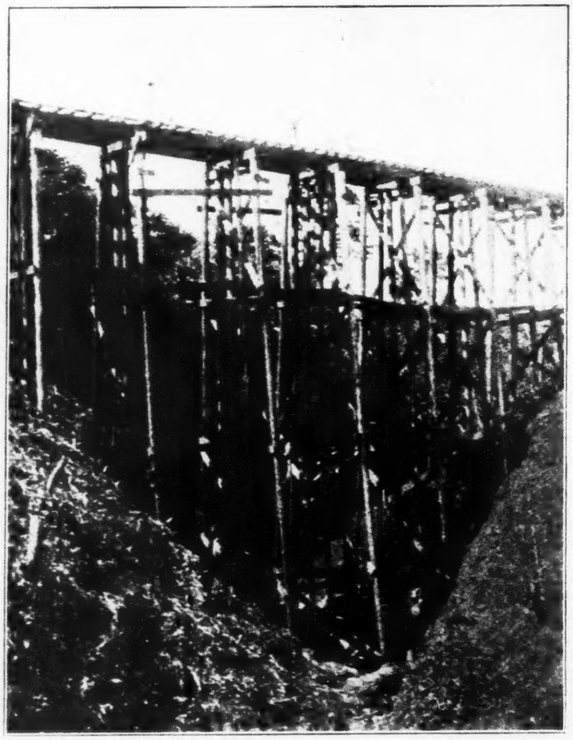


Fig. 12.—Temporary Trestle, Gatun Ridge.

Commission, indicated the possibility of such a change, and showed that the ridges were narrow in places. Surveys were made along the Bohio, Agua Salud, and Baldo Espino ridges, seeking low saddles where the contour maps indicated, through which a lcoation could be made. Such saddles were found and the line relocated accordingly. A further change was made between Frijoles and San Pablo along the same lines; that is, moving the line back from the edge of the lake into the hills. The map of the Canal Zone, Fig. 8, shows these changes. In addition to greatly reducing the amount and degree of curvature, these changes in location also give a line which can be shortened five miles by building a four-mile freight cut-off from Mount Hope to join the line again just north of Gatun river crossing, as is also shown in Fig. 8. This is the line on which it was proposed to build and operate a spur track from Mount Hope to Gatun.

Fig. 13.—Shoo-Fly Line.

Some Unusual Features in Construction.

At a point 800 ft. south of the Gatun station a high embankment carries the relocated line across a valley 1,600 ft. wide, which joins the main Gatun valley at this point. Seven hundred feet of this embankment is from 80 to 85 ft. high, as shown on the map and profile, Fig. 9. The permanent relocated line occupies the center of this embankment, and along the west side is the temporary connection track, known as the 1¼ per cent line, which leads from the relocated line at Gatun station (elevation 95 ft. above sea level) to the old line at Tiger hill (elevation 22 ft.) The valley which this embankment crosses will eventually be an arm of Gatun lake. It was originally planned to build this fill in three decks and to use the excavated material from Gatun locks. This material being entirely rock, side slopes of 1½ to 1 and top width of 30 ft. were planned. The base of the fill up to elevation 30 above sea level, con-

Fig. 15.—Slide, South Side Micapton Ridge.

taining 80,000 cu. yds., was placed as contemplated during the months of September, October, November and December, 1907. In the months of November and December, 1907, a connection track 2,000 ft. long was built from the Gatun lock side in order to place filling from the second deck, a trestle 30 ft. high being driven across the embankment at an elevation of 60 ft. above sea level. This trestle was filled during January and February, 1908, without serious difficulty, the only occurrence

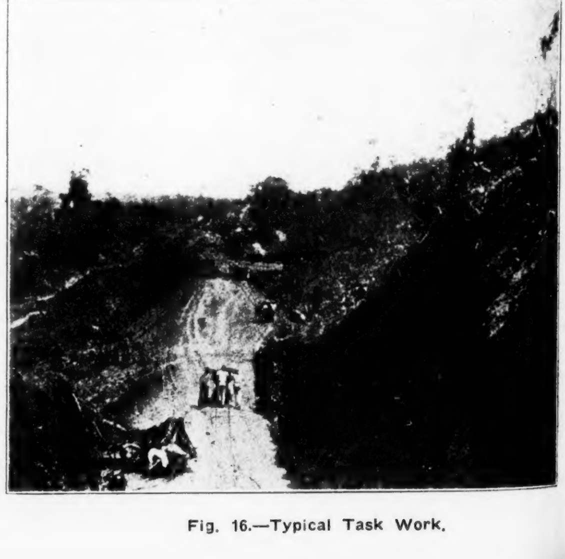


Fig. 16.—Typical Task Work.

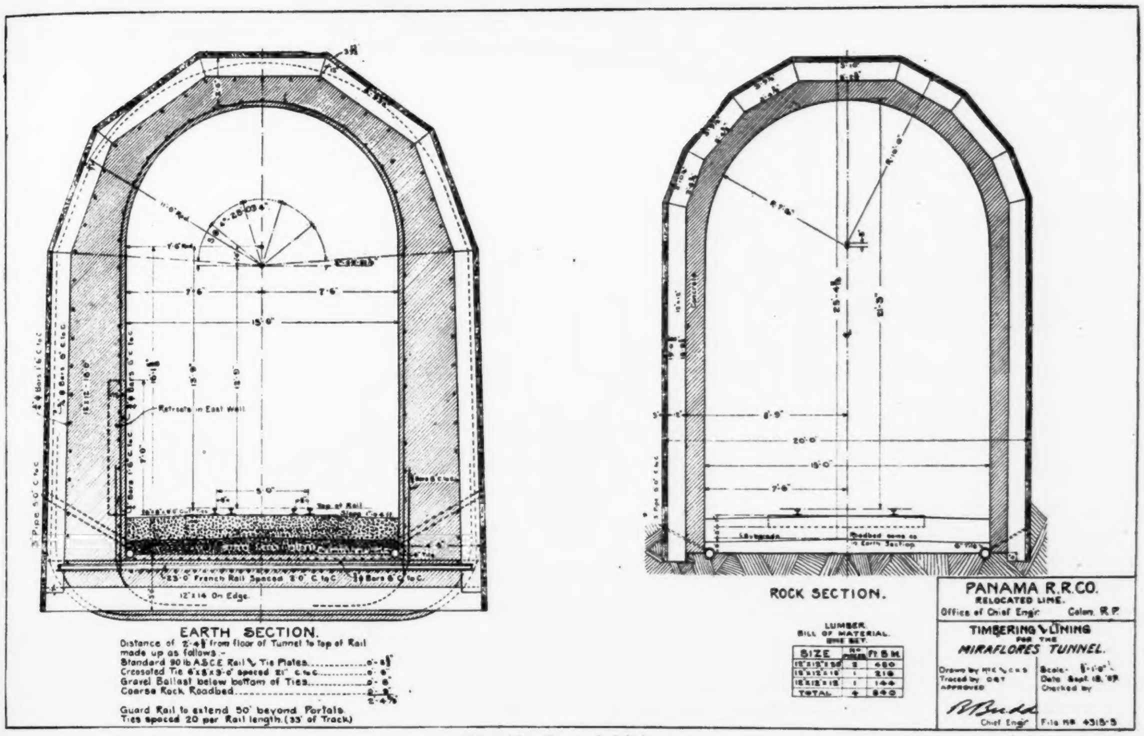


Fig. 14.—Tunnel Lining.

being a slide where the embankment crossed the old creek bed and involving movement of about 5,000 cu. yds. of material. This was not considered unusual, as it is a condition commonly met in such work. During the night of March 26, after completion of the third deck trestle, which was driven at the elevation of the 1¼ per cent Gatun-Tiger hill line, and after about 100 ft. of this trestle had been filled from the north end (elevation 90 ft. above sea level at this point), a very large slide occurred, carrying the tracks on the first and second decks several feet out of line and lifting the ground at the base of the embankment 10 to 12 ft. upwards over an area of about 50 ft. by 150 ft. This slide was apparently due to the placing of a large amount of filling against the hillside which rested on an inclined rock surface, causing all the material above the rock to slip. Up to this time, 166,000 cu. yds. of material had been placed in the embankment. Dumping on the center line was now abandoned and the bottom of the embankment was widened by raising the first deck track to elevation 35, and then throwing it over to the west. This was the condition at the close of the fiscal year, June, 1908. The work was continued along these lines until in September, when 50,000 cu. yds. had been deposited as a counter-weight along the west side of the fill. During October, November, December and January, the fill was brought up to the level of the third deck, a total of 337,000 cu. yds. having been placed up to this time. Throughout this process several bad slides occurred, not through slipping off the steep hillside as at first, but by displaceing the clay which overlaid the rock to a depth of 50 to 80 ft. on the east side, and from 100 to 125 ft. on the west. All these slides occurred toward the west. The counterweight had been added to during this

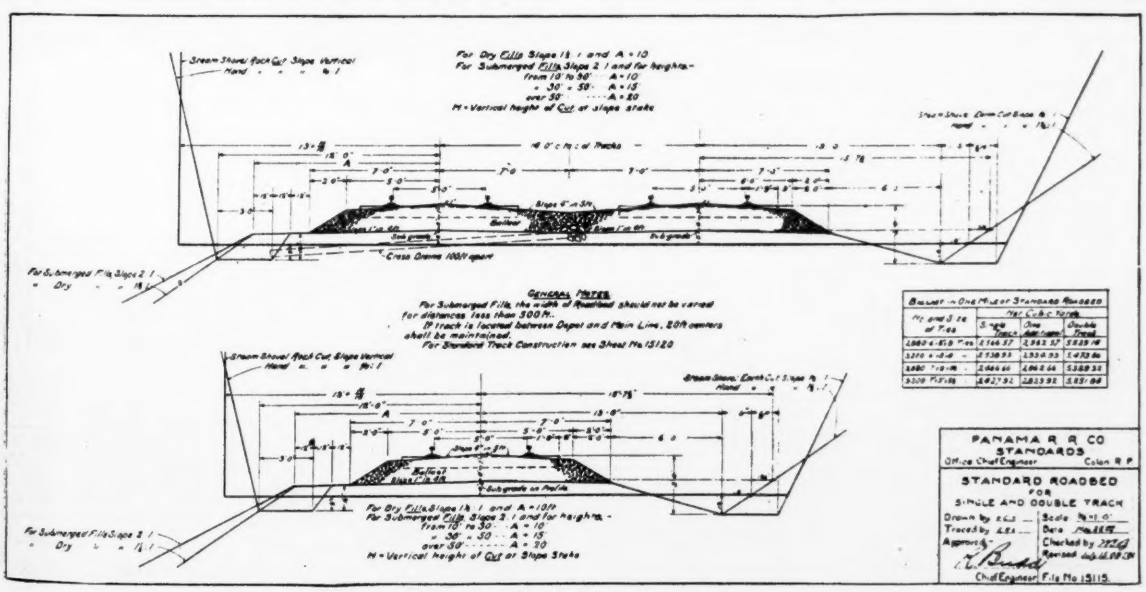


Fig. 17.—Standard Track Construction.

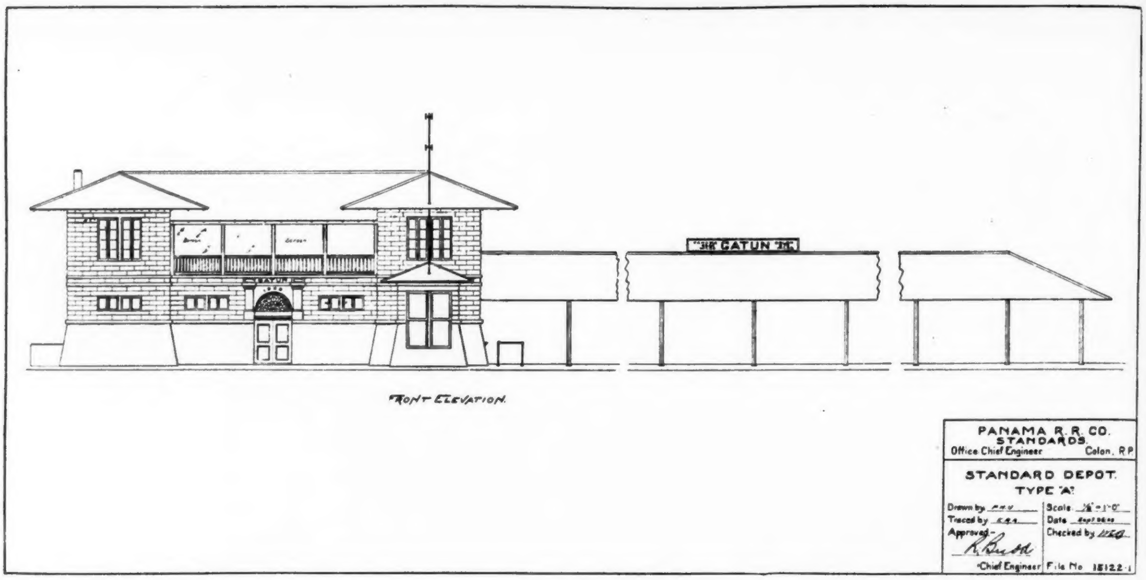


Fig. 18a.—Standard Station.

period and by the end of January it was very large, making, together with the bulging up due to slides, a slope of about 6 to 1 on the west side of the embankment. It was now considered safe to raise the embankment to final grade, elevation 95 ft. above sea level. On March 21, when practically up to grade and when the embankment was considered to be about completed, a slide occurred to the east, or up-hill side, displacing about 50,000 cu. yds. of material, with a vertical settlement of about 30 ft. for a distance of about 300 ft., as shown in accompanying photograph, Fig. 10. In Fig. 11 is shown the same embankment a few days prior to the slide. This was the first movement esatward. The method employed on the west side, that of building a counterweight, was now resorted to on the east side as well, and after continuing this until June 1, filling was resumed on the center line, and by June 15 had reached two feet above final grade, with a top width of 40 ft. and side slopes that will average about 6 to 1 on the west and about 3 to 1 on the east side. The actual amount of material deposited was 528,000 cu. yds. To have built a fill 40 ft. wide on top, with side slopes 2 to 1, would have required 293,000 cu. yds.

Fifteen hundred feet south of the high Gatun fill the line turns sharply to the left and follows along the south side of the ridge, which extends eastward from Gatun dam and forms the rim of Gatun lake. The line follows this ridge for about four miles, where it makes another sharp turn, this time to the right, and crosses the Quebrada Ancha, Quebrada Baja, and Gatun valleys, which converge into one between here and where the original relocation crossed between Gatun and Tiger hill. The south slope of this ridge is more or less cut up by gullies, and numerous ridges extend out between these gullies. The method of construction has been to build as much as possible by benching into the side hill and casting over with steam shovels, driving pile trestles across the intervening gullies.

A temporary trestle 250 ft. long and 70 ft. high across one of these gullies is shown in Fig. 12. By this method the track is pushed ahead with the least possible amount of work until the large valleys are reached, when the entire side hill along

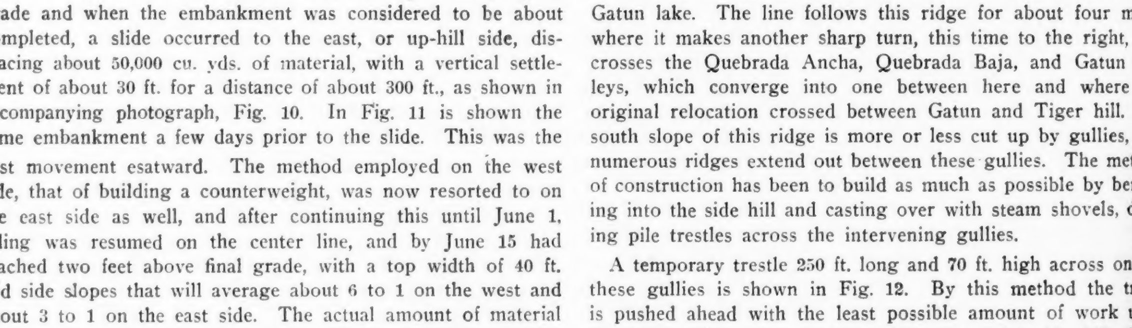


Fig. 18b.—Plan of Gatun Station.

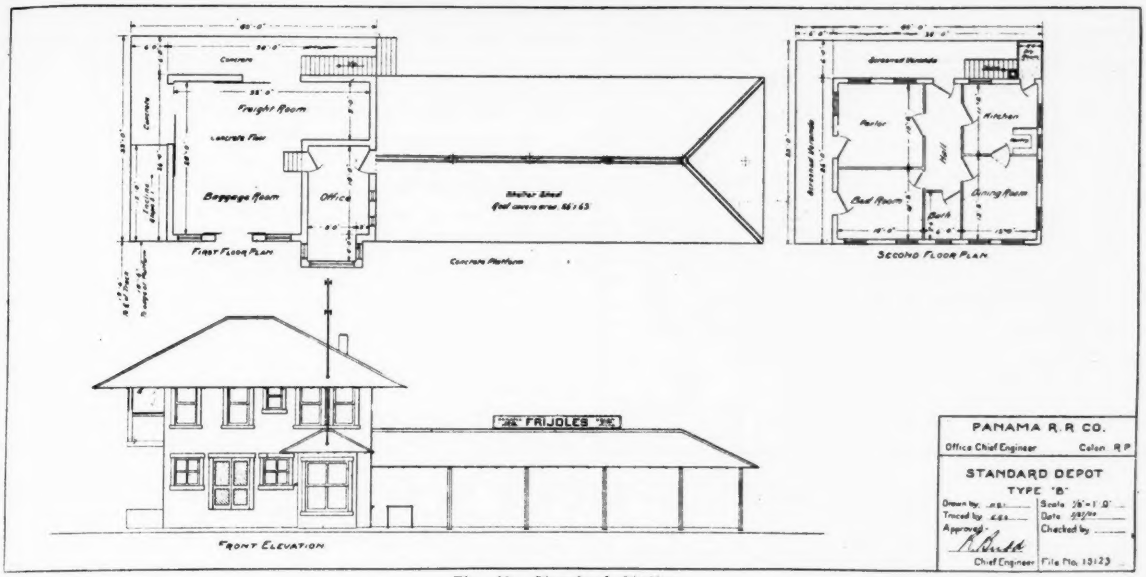


Fig. 19.—Standard Station.

the ridge can be developed into a borrow pit for obtaining material to make the embankment, at the same time grading a very good roadbed in solid rock excavation, safe from slides, where the completed track will be located.

As the new line lies so far from the present one in the section south of Gatun, it is necessary to build that part of the line be-

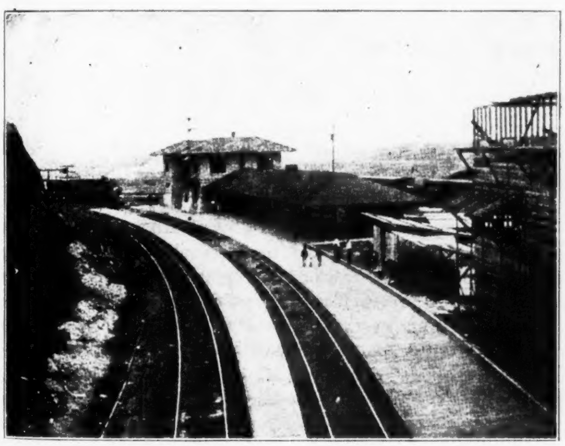


Fig. 20.—Station at Gatun.

tween Gatun and Frijoles (12 miles) by working south from Gatun and north from Frijoles, no connection tracks being possible from the old line. This kind of construction is most difficult in the tropics, owing to the dense growth of vegetation and the difficulty of getting material and subsistence supplies. The method employed is to establish camps as far ahead of the tracks as possible, so as to have the cuts excavated in advance of pile driving which is necessary across the numerous wide valleys. Pile driving is hastened where trestles of from ¼ to ¾ of a mile in length are required, by laying a track across

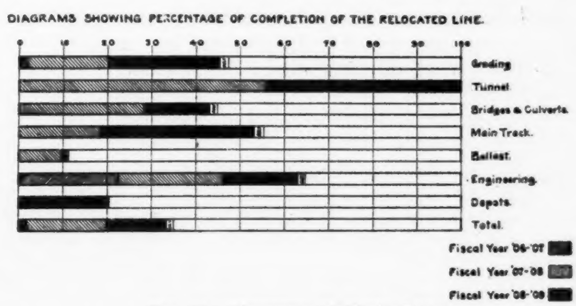


Fig. 21.—Diagrams of Work Done.

the valley and backing a pile driver across on this track, then starting it driving from the far end to meet the driver which starts at the end of the track, the track in the bottom being used meanwhile to supply the materials to the two drivers.

In Fig. 13 is shown two pile drivers about to meet in the middle of a 3,000 ft. trestle and also shows at the left the temporary track. A Lidgerwood unloader is usually employed at the end of the track in such cases to let down the loaded cars, and to pull up the empties after they have been placed by the smaller engines and unloaded on the lower track.

During the dry months, January to May, 1908, excavation of

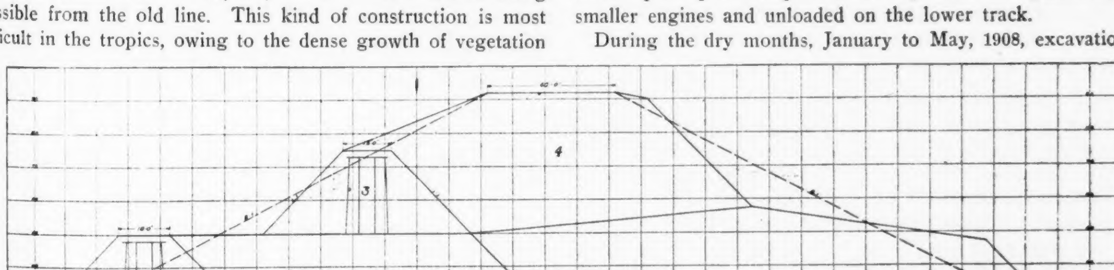


Fig. 22.—Order in Construction, High Embankment.

PHYSICAL STATISTICS.		OLD LINE	RELOCATED LINE.
Distance Colon to Panama		47.27 miles	46.18 miles
Number of Tracks		Double Track ~ 32.64 miles Single Track ~ 14.63 miles	Single Track
Gauge of Track		5'-0"	5'-0"
Weight and Section of Rail		13.01 miles Track - 90# A.S.C.E. Remainder - 70# A.S.C.E.	70# A.S.C.E.
Kind of Ballast		Gravel	Gravel
Total Rise and Fall		427.5 Feet	208.0 Feet
Maximum Gradient ~ North Bound		1.50% Comp.	0.45% Comp
" " ~ South Bound		1.45% Comp	1.25% Comp
	1°	42° 21'	334° 29'
	2°	264° 42'	419° 57'
	3°	523° 58'	382° 16'
	4°	841° 10'	262° 54'
Distribution	5°	587° 49'	101° 00'
of	6°	833° 51'	491° 16'
Curvature	7°	226° 13'	None
	8°	331° 49'	None
	9°	322° 30'	None
	10°	319° 41'	None
	11°	155° 47'	None
	Total	4449° 51'	1991° 52'

Fig. 23.—Comparison of Old and New Work.

the Miraflores tunnel bore had been practically completed, and temporary timber lining had been placed throughout almost the entire length. The north 400 ft. of this tunnel passes through solid rock, and the south slope of this rock lies at about an angle of 45 degs. The excavation of the south portal of the tunnel so distributed the equilibrium of the earth which forms the south side of the Miraflores ridge, which the tunnel pierces, that during the months of July and August the entire side hill, involving about 200,000 cu. yds. of material, began moving southward along the axis of the tunnel and also slightly eastward, at an angle of about 20 degs. from the direction of its axis. This carried the earth section of the tunnel with it and literally twisted the tunnel to pieces. The timbering in the earth section, 200 ft. long, collapsed in September. The rock section, 421 ft. at the north end, was not affected and was lined with concrete during September, October and November. Work was discontinued in the earth section until the beginning of the dry season, January 1, when the tunnel was again opened up on the original center line and grade, and was completed in April, 1909.

The reinforced concrete lining of the earth and the rock sections, also the roadbed as built, is shown in Fig. 14. A track was laid and heavy rock placed to refill the hole in the south side of the hill, caused by the slide. The illustration, Fig. 15, from a photograph, shows this work about completed, and also shows the extent of the slide. The small summit at the right was originally about on the center line. The escarpment on the side of the main hill indicates where the slide broke off. The tunnel was lengthened 50 ft. at the north end and 91 ft. at the south end, to provide for flatter slopes on the sides of the hill due to slides. Its length on completion was 736 ft. from portal to portal, instead of 595 ft. as originally contemplated.

Bridges and Culverts.

On the completed line there will be two steel bridges carried on reinforced concrete piers and abutments. One of these, spanning the Chagres river where it enters Gatun lake at Gamboa, has been described above. The other will be a bascule bridge at the Gatun river. All of the other rivers and streams will be carried through culverts below sub-grade. These culverts are being built from 15 to 20 ft. above the bottom of the stream. The backing up of water is of slight importance for two reasons: First, the land is uncultivated and is already owned by the Isthmian Canal Commission, or will have to be purchased before being submerged by Gatun lake. Second, when the lake is formed, all land on both sides of the line below elevation 85 above sea level, will be permanently flooded. By placing the culverts high against a rock side hill, good foundations, without piles, are often obtained, where it would have been necessary to go to great expense had the culverts been located in the bottom of the valley. Furthermore, with embankments having side slopes of 2 to 1, each foot the culvert is raised shortens it by 4 ft.

Three types of concrete culverts are used: reinforced concrete arches, reinforced boxes, and vitrified pipe culverts. Gravel concrete has been used almost exclusively, the gravel being obtained from deposits in the Chagres river.

On all of the smaller cuts, and in many cases to open up for a temporary track to start steam shovels, the so-called "task system" of labor is used. By this method the laborer is paid for carloads of material moved rather than for his time. A price of 8, 9 and 10 cents for each Decauville car (about 1-3 cu. yd.) was fixed upon, depending on the length of haul and the inaccessibility of the work. No classification of material is made, as the railroad company does all blasting necessary to get the rock into pieces small enough to be handled by hand. A West Indian laborer can be employed to especial advantage by this method. A number of negroes co-operate, some doing digging and loading and some dumping and spreading.

The company requires that at least fifteen cars be loaded by each man for his day's work. Frequently this "task" will be finished in six hours, while on the hourly basis it would hardly be done in nine. A typical "task" gang at work is shown in Fig. 16.

The section of roadbed used is rather unusual, owing to local conditions. Ample width is required in excavation, owing to the enormous rainfall, and it can be provided without extra expense, as the embankment quantities are so largely in excess. The extra width and flat slopes provided on the embankment are on account of their being submerged, as indicated on the standard roadbed plan, Fig. 17.

Stations.

Two types of stations are provided, as shown in standard plans, Figs. 18 and 19. One type "A" station has already been built at Gatun, as shown in Fig. 20.

The diagram, Fig. 21, shows the general progress of the work to date. The new railroad will be practically completed during the present fiscal year, except building the two miles across the Quebrada Ancha, Quebrada Baja, and Gatun river valleys. Track will be carried across these valleys on temporary trestles at a minimum elevation of 50 ft. above sea level, and the embankments will be built by the methods shown on cross section, Fig. 22, the successive operations being numbered from 1 to 4. The total yardage in these embankments will be about 3,500,000 cu. yds. The minimum elevation of the old railroad in the Gatun lake region is 20 ft. above sea level. The present line will be used until the water in the Gatun lake reaches this elevation of 20 ft., when the new line will be put into use between Gatun and Bas Obispo, where a connection will be made by building a trestle across the canal, as shown in Fig. 8. The old line will then be used from Bas Obispo to Paraiso until the Culebra cut is completed.

Questions for Discussion at the International Railway Congress

Following is a list of the questions which are to be discussed at the eighth session of the International Railway Congress, to be held at Berne, Switzerland, next July, together with a list of the reports that are to be made, i. e.: under the first subject a report is to be made covering France, Belgium, Italy, Spain and Portugal; another covering Austria-Hungary, Rumania, etc.; another covering countries using the English Language, and another for all other countries. We give the

names of the "reporters" who will represent English-speaking countries.

Section I.—Way and Works.

I.—Rail-Joints.

A. Reduction in the number of joints by increasing the length of the rails. Maximum length to be adopted for ordinary track rails. The welding of rail-joints.

B. The strength of rail-joints.

France, Belgium, Italy, Spain and Portugal; Austria-Hungary, Rumania, Bulgaria, Servia, Turkey and Egypt; countries using the English language, Mr. Ross, Great Northern Railway, London; other countries.

II.—Strengthening the Track and the Bridges with a View to Increasing the Speed of Trains.

A. Increasing strength of road on account of increased weight of locomotives and speed of trains. Means for increasing the speed on curves without increasing the superelevation of the outer rail to a corresponding extent. Economy of maintenance to be realized from the use of a stiffer track. Cross-section and quality of the rail. The spacing of wooden sleepers and their seats. Substitution of other materials for wood in making sleepers.

B. The suitable strengthening of existing metal bridges proportionately to the increase in the weight of the locomotives and in the speed of the trains.

Austria-Hungary, Bulgaria, Rumania, Servia and Turkey; America, Mr. Byers, Missouri Pacific, St. Louis; Spain and Portugal; France and Italy; Holland and Belgium; Russia; Great Britain, Mr. Jacomb-Hood, London & South Western, London; Other Countries (A); Other Countries (B).

III.—Junctions and Swing Bridges. Elimination of Slacking.

Arrangement of the road appliances for passing at high speed over switches and swing-bridges.

France, Italy, Spain and Portugal; Great Britain, Mr. Morgan, London, Brighton & South Coast, London; America, Mr. Besler, Central of New Jersey, New York; other Countries.

IV.—Long Railway Tunnels.—Construction, Ventilation and Operation.

Methods used in constructing, ventilating and operating long railway tunnels.

Submarine tunnels: Alpine tunnels; great town tunnels in Great Britain, Mr. Fox, consulting engineer, 28 Victoria street, Westminster, London; tunnels in mountainous countries (the Alps excepted) and great town tunnels (Great Britain excepted).

Section II.—Locomotives and Rolling Stock.

V.—The Use of Steel. Special Steels.

A. Use of steel in the construction of locomotives and rolling stock; freight and passenger wagons entirely of steel.

B. Use of special steel of high resistance in the making of the various parts of locomotives and rolling stock (tires, axles, springs, couplers, boilers, etc.)

America (A), Mr. Crawford, Pennsylvania Lines West of Pittsburgh, Pittsburgh; all countries except America; America (B), Mr. Ettinger, Southern Railway, Washington; countries belonging to the German Railway Union; Great Britain (B), Mr. Worsdell, North Eastern Railway, Gateshead; other countries.

VI.—Improvements in Locomotive Boilers.

A. Boilers with smoke tubes; precautions in constructing and maintaining tubes and tube-plates.

B. Boilers with water tubes. Steam superheaters and valve gear for superheated steam. Feed water heaters.

C. Damages to boilers, blisters, cracks and corrosions. Means employed for preventing these damages. Purification of the water and disincrustants or antifouling compounds.

Russia (A and C); America (A and B), Mr. Vaughan, Canadian Pacific, Montreal; Austria-Hungary, Rumania, Bulgaria, Servia and Turkey (B); Russia; France, Belgium, Italy, Spain and Portugal (B); Austria-Hungary, Rumania, Bulgaria, Servia and Turkey (A and C); France, Belgium, Italy, Spain and Portugal (A and C); Great Britain, Mr. Fowler, Midland Railway, and Mr. Archbutt, Midland Railway, Derby; other countries.

VII.—Steam Locoomtives for Very High Speeds.

Steam locomotives for obtaining regulation speeds exceeding 60 miles an hour.

America, Mr. Garstang, Cleveland, Cincinnati, Chicago & St. Louis, Indianapolis; other countries.

VIII.—Electric Traction.

Electric traction on large railways. Continuous current. Alternating current (monophase or polyphase). Comparative net cost.

Germany; America, Mr. Gibbs, Long Island Railroad, New York; other countries.

Section III.—Working.

IX.—Large Stations.

A. Large passenger stations.—Best arrangement of tracks so as to increase their working capacity and ensure safety in shunting operations. Improved mechanical appliances for the conveyance of luggage, etc.

B. Large Goods Stations.—(1) Arrangements of tracks; (a) to allow the continuity of movement of vehicles which require shunting and which are separate from the time the train bringing them has arrived until the train taking them away is being made up; (b) to prevent such movement from being interfered with by the arrival or departure of trains; (c) to stop without shock such separate vehicles at the end of the successive movements required; (d) to start them off again.

(2) New appliances for handling goods.

America, Mr. Jaggard, Pennsylvania Railroad, Elmira; Russia, Austria-Hungary, Rumania, Bulgaria, Servia and Turkey; other countries.

X.—Operations of Switches and Signals.

A. Improved centralized installations for operating switches and signals. The use of water, of compressed air, of electricity, for working the transmissions. Electric interlocking. Route levers.

B. Arrangements adopted to prevent switches taken from the facing or the trailing side from changing their position before the whole train has passed.

C. Use of diagrams to facilitate the consideration of the full utilization of tracks along passenger platforms and the modifications to be made, in cases of urgency, in the way these tracks are used.

Holland; Austria-Hungary, Bulgaria, Denmark, Germany, Luxemburg, Norway, Roumania, Russia, Servia, Sweden, Switzerland and Turkey; America, Mr. Carter, Chicago & North-Western, Chicago; Other Countries.

XI.—Passenger Tickets.

Different types of passenger tickets. Systems enabling the number of blank tickets to be reduced. Simplified tickets for stopping places. Apparatus for printing tickets (and checking them) as and when required.

All Countries.

XII.—Motor Vehicles.

The use and cost of motor vehicles or self-moving cars.

Great Britain, Mr. Riches, Taff Vale Railway, Cardiff; America, Mr. Clark, Buffalo & Susquehanna Railroad, Buffalo; Other Countries.

Section IV.—General.

XIII.—Railways and Waterways.

The investigation of the influence of waterways considered as feeders and as competitors, on railways.

Great Britain, Mr. Jebb, Shropshire Union Railways and Canal Company, Birmingham; America, Mr. Hoyt, New York Central Lines, Rochester; Other Countries.

XIV.—Statistics.

A. Principles of statistics of railways in operation.

B. Uniform classification of working expenses.

Great Britain, Mr. Acworth, The Albany, Piccadilly, London

W.; English Colonies, Mr. Price, general manager, Central South African Railways, Johannesburg; Other Countries.

XV.—Motor Car Services.

Porterage, cartage and connecting services by motor car.

All Countries, Mr. Inglis, Great Western Railway, London.

XVI.—Perishable Goods.

Suitable measures for developing the traffic in perishables; packing, refrigerator vans, appliances for keeping temperature constant, etc.

Countries using the English language, Mr. Culp, Southern Railway, Washington; Other Countries.

Section V.—Light Railways.

XVII.—Lines Belonging to Main Railways but Having Not Much Traffic.

Simplification in operating lines belonging to main railways but having not much traffic.

All Countries.

XVIII.—The Working of Light Railways.

Examination of the results of the different systems used in operating light railways (leasing, operating jointly with corresponding main railway, working by concessionary himself, with or without guarantee or subvention from the authorities granting the concession.)

All Countries.

XIX.—Locomotives and Rolling Stock of Narrow-Gage Light Railways.

A. Types of the latest locomotives used on narrow-gage light railways, with due consideration to the profile of the line and the class of traffic.

Is it advisable: (1) to protect the wheels and the moving parts by a metal cover; (2) to have a foot-plate at each end of the locomotive? What regulations are there on the subject?

B. What are the latest types of carriages and wagons used on narrow-gage light railways?

All Countries.

XX.—Transshipment.

Examination of the different systems adopted for the exchange of goods between lines of different gages (transshipment at the same level, sunk or raised tracks, trucks for taking cars of another gage, tracks with three or four lines of rails, etc.).

All Countries.

Note on the Utility of Studying the Question of Freight Car Interchange and Demurrage.

A. Regulations for the interchange use of freight cars between railways and penalties for delays and misuse of freight cars by railways.

B. Regulations to prevent delays and misuse of freight cars by shippers and consignees.

By Mr. Allen, secretary, American Railway Association, New York.

Long Island Railroad Offices in Manhattan

The Long Island Railroad has abandoned its plans for putting up a $1,000,000 office building in Jamaica, and intsead will build a less expensive two-story structure to provide offices for the division superintendent, dispatchers, trainmen, paymaster and minor officers.

The principal offices of the company will be transferred about August 1 to the new Pennsylvania Terminal building, at Thirty-third street, Manhattan, where the offices of the president, general superintendent, real estate agent, purchasing agent and the electrical superintendent will be established. The Long Island will rent the entire third floor of the Pennsylvania station, at the Eighth avenue end of the building. The office space thus acquired will have a frontage of 250 ft. on Thirty-third street, 250 ft. on Thirty-first street, and the whole length of the building on Eighth avenue (about 470 ft.)

Besides the offices of President Peters and the others named, the legal department, the claim department and the general secretary will be moved from Cedar street, Manhattan; the offices of the traffic manager, the general passenger agent and the auditor, from Twenty-ninth street, Manhattan, and the office of the chief engineer of electric traction, which is a joint office of the Long Island and Pennsylvania roads, will be moved to the Pennsylvania station. About 200 men in all will thus be transferred.

At Jamaica will be the offices of the superintendent, the trainmaster, paymaster, superitnendent of police, superintendent of stations, car record office, chief surgeon, relief association and superintendent of express. This will involve the transfer of 100 men from Long Island City.

The offices of the chief engineer and the engineer of maintenance of way, now in Jamaica, will remain there.

The Philadelphia & Reading is planning to erect a large interlocking plant at the junction of the Lebanon Valley and the Lebanon & Tremont branches, near Lebanon. It will be a 76-lever plant and will control all the movements over the junction.

The Chicago Great Western will buy all the signals and relays to equip its tracks between Chicago and Oelwein from the General Electric Co.

The Rock Island has just completed the installation of automatic block signals between Valley Junction and Neola. There are 136 signals and three crossing bells. The signals, indicators and relays were furnished by the Union Switch & Signal Co. and the concrete battery wells by the Massey Co.

The Railroad Commission of Texas has approved the plans for the interlocking plant on Walker avenue, in Houston, protecting the crossings of the Houston Belt & Terminal, the International & Great Northern and the San Antonio & Aransas Pass. The plant will be in operation in about a month.

Report on the Operation of Switches and Signals in America *

By E. C. CARTER.

(1) This question runs as follows: "*A.* Improved centralized installations for operating switches and signals. The use of water, of compressed air, of electricity, for working the transmissions. Electric interlocking. Route levers.—*B.* Arrangements adopted to prevent switches taken from the facing or the trailing side from changing their position before the whole train has passed.—*C.* Use of diagrams to facilitate the consideration of the full utilization of tracks along passenger platforms and the modifications to be made, in cases of urgency, in the way these tracks are used."

A review of the conditions existing in the United States at the present time, with reference to the operation of switches and signals, develops the following.

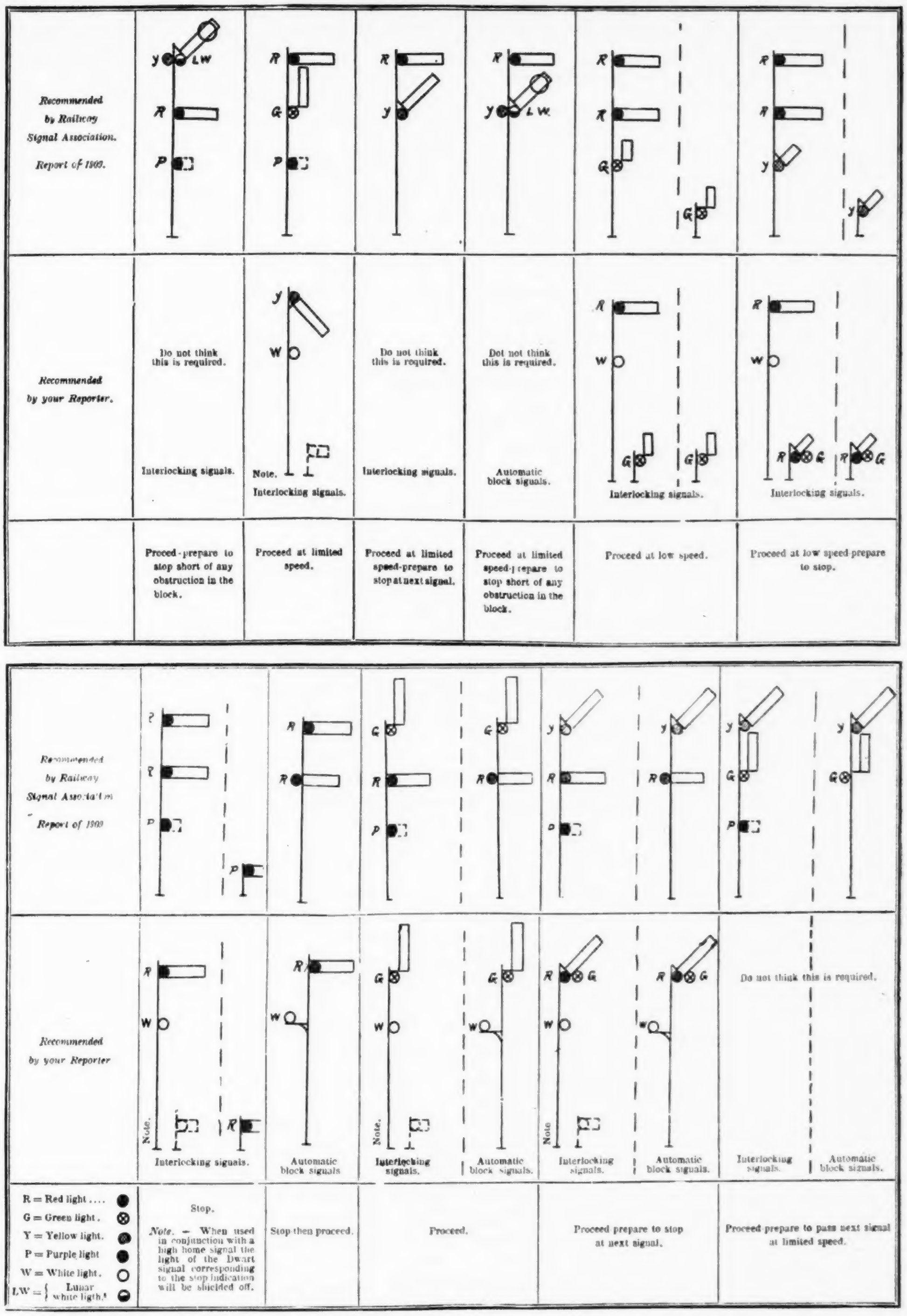
A.—Centralized installations for operating switches and signals ,are limited:

First, to those in which the required movements of the functions are made by manual force through mechanical connections brought to a central point, and

Second, to those in which some form of stored power is controlled from a central point for such operations.

The first is represented by the mechanical interlocking mechanism which is in such general use throughout the world as to require no particular description. There has been, in America, very little, if any, change in the details of the apparatus or of its installation for a number of years. The use of 1 inch pipe connections is universal for the operation of switches, movable point frogs, draw bridge couplers, and their respective locks, compensated for the effects of temperature changes by an equalizing system of cranks and levers. It is also very generally

*From the Bulletin of The International Railway Congress.



Comparison of Signal Indications.

used for the operation of home signals. Wire connections (one wire for the front connection and one for the back) are still used for the operation of distant signals which can be located not over 1,300 to 2,000 feet from the tower, but when the signal has to be located at a greater distance, liquid carbonic acid gas, stored in steel bottles, or electricity, derived from a battery, is used as the source of operating power, located at the signal and controlled electrically from the tower.

The second comprises those in which hydraulic, pneumatic, or electric power is stored and used for the operation of the various functions.

Owing to the severe climatic conditions which continue in winter for from two to four months throughout the northern portion of America the use of hydraulic switch and signal apparatus is subject to such derangement and such interruptions in operation as to be very unsatisfactory. A small number of plants of this type have been installed but have been discontinued and replaced by other kinds which are free from the troubles which are inseparable from the use of liquids as a means of power transmission under such climatic conditions.

The use of compressed air has been quite extensive and has given a very fair degree of satisfaction as the means for operating switch and signal installations in this country. This kind of power application is represented by two types:

(a) The low pressure, in which the air is used at a pressure of from 15 to 25 lb. per square inch, and,

(b) The high pressure, in which the air is used at from 80 to 100 lb. per square inch.

The low pressure type has many points of excellence, but for some reason has not become very popular, probably on account of the great number of pipes leading to the switches and signals. Inquiry develops the fact that no plants of this type have been installed since 1905 and also that, as the existing plants require extensive reconstruction or renewal, this type is giving place to some form of all-electric apparatus.

The high pressure type is represented only by the Westinghouse electro-pneumatic system. A very large number of plants at large and complicated junction points and terminals have been installed and are in very satisfactory operation throughout the entire country. It is a recognized fact, however, that compressed air under high pressure is subject to a number of characteristic losses in efficiency, which will limit its use. The loss on account of the heat generated, due to the work of compression, is unavoidable and amounts to from 50 to 60 per cent of the energy expended in storing this kind of power. The loss due to leaks in the distributing pipes are variable but as the system grows older increase, and often become an element of serious expense, necessitating extensive repairs and renewals.

The application of all-electric interlocking plants has made rapid strides in the last eight or ten years and, as this type offers very superior advantages, it bids fair to take the lead. The reasons for this are:

(12 Its flexibility in application and use.

(2) In the storage of the power and its distribution the losses can be reduced to a very small figure.

(3) The distribution and application of the power is free from any inherent troubles due to variations or extremes of temperatures.

This type of interlocking development is represented by the product of four principal companies.

The common feature in all of the designs is the use of motors for the movement of switches by means of gears, a screw, a worm or by a cam motion plate, any one of these mechanical devices being susceptible of development to meet the requirements. Signals are operated generally by motor driven gears, dwarf signals sometimes being operated by solenoids.

All power interlocking is arranged so that the completion of the movement of the switch or signal gives a return indication at the machine in the tower, releasing the mechanical locking and insuring that the position of the switch or signal, as the case may be, corresponds with that of the operating lever.

The locking between the levers of the machine is mechanical, being generally of the same type as that for mechanical interlocking plants, though not made nearly so heavy, not being called on to withstand such applications of force as is usual in the manipulation of mechanical levers.

Electric locking of the levers in the interlocking machine may be arranged to effect the following in either mechanical or power operated plants:

Advance Locking.—This is generally used at points where trains pass at high speeds, to prevent the taking away of the route which has been cleared for an approaching train, the switch levers remaining locked until the train has passed or until the signalman has operated a releasing device which is arranged to take time, thus requiring deliberation and giving an interval during which the train can be stopped. The signal levers are never included in this advance locking but can, in their proper rotation, be restored to their normal positions at any time.

Detector Bar Locking.—Electric locking is used for this purpose in connection with track circuits in yards where such circuits are used in place of mechanical detector bars.

Route Locking.—This form of electric locking is used to lock all switches in a route so that they cannot be moved in advance of a train after the train has accepted the route, even though the mechanical locking on the machine has been released by the leverman in placing his signal lever in the normal position.

Release Route Locking.—This form of electric locking effects the consecutive release of each switch as and after the rear of the train has passed it and is only used in large and complicated terminals to save time.

Check locking is that form of electric locking between adjacent interlocking towers which are so near each other as to call for co-operative action of the signalmen in them.

Route levers, as known in Europe, have never become popular in the United States, it being considered an essential operating requirement that the plant should permit of any possible route combination of switches being given so as to cover irregular movements and emergencies.

B.—The use of track circuits in place of detector bars has become usual in complicated terminals and is considered as being safer than any mechanical devices for this purpose, it being possible with such circuits to prevent the movement of the switches while the train is passing over them and may be arranged so that the train is wholly clear of any adjoining track or switch before another train can be permitted to pass that point. In plants where the spacing of the switches is such as to permit it, mechanical detector bars, either inside or outside of the rail, are still generally used, though it is evident that, with the increasing use of heavier rail sections which have materially wider heads, such use must be limited to bars of the inside type.

In heavily worked, large, and complicated terminals a miniature track model is generally provided on the interlocking machine for the information and convenience of the levermen. Formerly, this model was arranged to show the movement of the switches corresponding to the movement of the levers, but with the greater perfection of the return indication apparatus which controls the operation of completing the stroke of the lever, the model has been used to indicate the occupation of tracks or of two or more sections of a track as may be needed. An indication is often provided showing the failure of any train to wholly clear an adjoining track. One of the most complete and elaborate installations of this later type is that provided for the operation of the new Union Terminal at Washington, D. C. Each standing track in the depot has an independent track circuit fed through a resistance from a single supply circuit, the track relays all being in the tower at the outer end of the yard. In the tower and over the interlocking machine is arranged a large track model, covered with ground glass, on which the track arrangement of the station is outlined. So long as a track is unoccupied and is not fouled by cars on an adjoining track, that particular track on the model is illuminated from behind the glass. As soon as it is occupied by a car or train the lights are extinguished. It will be seen from this that these indications are given from a closed circuit, which is used preferably on account of its indicating at once any derangement in the circuits and is generally considered to be the only safe way in which track circuits for this or any other purpose can be used.

This station is also provided with a very complete system of communication between the director of the interlocking tower, the train conductors on the different departure platforms and the gateman controlling the admission of passengers to those platforms. In the interlocking tower, in front of the director, there is a bank of indicator lights arranged one above the other, three for each track, the upper light being the return indication from the train conductor, the middle light an indication to the conductor and the gateman, and the lower light an indication from the gateman. Adjoining each gate there are two incandescent glow lights on the circuit, one above the other, con-

nected in such a way that the gateman, by inserting a special key, can complete a circuit to the tower.

At four points, distributed along the platform, are located boxes on the columns supporting the umbrella shed, each box having two glow lights, one above the other, the boxes being so arranged that the conductor of a train, by inserting a special key, can likewise complete a circuit with the tower. The method of using this system of communication is as follows:

One minute before the departure time of the train, the conductor inserts his key in one of the boxes on the platform and turning it closes the circuit which lights the upper light for the corresponding track in the bank of lights in front of the tower director and likewise lighting the upper of the two glow lights at the gate. If the director is ready to have the routes given for this train, he presses a button which puts out the top light given by the conductor and lights the one next below it and lights the top light in each of the boxes along the platform and puts out the upper and lights the lower of the two lights at the gate. When the time has arrived for the train to go, the gateman closes his gate and with his key puts out the light at the gate. This also puts out the upper and lights the lower of the tower indicator lights, in this way advising the conductor and the towerman simultaneously that the train may leave. The conductor may then give his usual starting signal to the engine runner to go, which he then does, provided the proper fixed signal is clear. This arrangement provides a very simple and accurate system for transmitting the required information and works perfectly.

C.—The use of diagrams for facilitating the full utilization of tracks along passenger platforms.

Inquiry of the roads in this country having the largest terminals develops the facts that no such diagrams are used or are considered as being necessary for the distribution of trains at platforms, experience having proved that the familiarity of the director in the tower with the station lay-out and the information which he receives in advance as to the trains to be handled is such that the desired results can be better obtained by relying upon his skill.

The foregoing covers about all the points that are raised by the questions which are submitted for discussion, but it is believed that in this same connection it will be interesting to present a discussion which has been under consideration by those interested in signaling of the various railways of the United States during the last three years. In general, the practice in America has been to give the indications of fixed semaphore signals for both interlocking and automatic block signals in the lower right hand quadrant, usually by two positions, the home signal being horizontal for "stop" and diagonally downward or vertically downward for "proceed," and the distant or caution signal (the end of the blade being of a different form from that of the home signal, being notched or fishtailed, whereas the end of the home signal is square) indicating in the horizontal position "caution" and diagonally downward or vertically downward indicating "clear." The extensive application of automatic semaphore block signals and the attempt to carry the block working through more or less complicated interlockings has led to considerable diversity of practice on different lines, and the automatic block semaphore, both home and distant, being of the same form as the home and distant semaphores for interlocking plants has led most naturally to a possible confusion on the part of the engine runner in the interpretation to be given for a given signal indication, especially when in its normal position, which, for an interlocked semaphore indicates "stop and stay" and for an automatic block signal semaphore indicates "stop and proceed with train under control." The practice on different roads in connection with interlocked semaphores at points where a number of routes are to be indicated has also varied, a number of the older lines having a home signal blade for each route, placed one above the other on a single mast, and other roads for similar situations having only two, the upper for the main high speed route and the lower for diverging routes.

Figure or letter indicators combined with the lower blades, under the two blade system, have been tried but were discarded as of no value corresponding to the complication or cost due to their use.

The consolidation of different railway properties under one management has brought together lines having both systems in use and the necessity for unifying the practice over the whole of such a consolidated line and doing it in such a way as would provide for the future as well as the present requirements led to a very prolonged and exhaustive investigation by committees appointed by the larger lines interested in the question, and later by committees of the Railway Signal and Maintenance of Way Associations. The result of these investigations was the statement of a series of fundamental principles and of the rules which should govern any applications under those principles.

The first and most radical departure was the use of the upper right hand quadrant for giving signal indications, in this respect following the German practice.

Secondly, the giving of three indications by one signal blade, one by the blade displayed in a horizontal position and pointing to the right, one by the blade pointing upwardly at an angle of 45 degrees and one by the blade pointing in a vertical direction upwardly.

Thirdly, the use of a second blade below the first, which in turn gives three indications by similar positions to those of the first or upper blade.

Fourthly, the distinguishing of interlocked semaphore signals from automatic semaphore signals by having the ends of the interlocked signal blades (when the blades were in a horizontal position) in the same vertical line, and by having the ends of the automatic semaphore signals (when the blades were in a horizontal position) so arranged that the upper blade projected further to the right than the lower blade.

The night signal lights were correspondingly arranged, one being vertically above the other for interlocked signals and for automatic signals the lower light being located diagonally below and to the left of the upper light.

The above combinations of three positions for two signals permitted of giving a considerable number of indications which were thought necessary for giving information to direct the movement at the high speeds at present required for through limited and special service trains.

It is generally admitted that the night indications should be given by lights of distinctive color, and the difficulty in giving so many combinations as above required has been solved by the use of green, yellow and red lights for the three positions of vertical, 45 degrees, and horizontal, though it appears to the writer that by far the most logical solution would have been green, red and green, and red for the corresponding positions, the red and green from one source of light having been proven by years of use on one or two of the largest systems in the country to be absolutely distinct and reliable.

Up to the point where two blades have been decided on for giving indications in combination, there has been a fair degree of unanimtiy in the ideas of those responsible for the system, but some divergence of opinion has developed as to the system by which the combinations shall be made and the great danger appears to be that greater confusion may result as between the practice of different roads in this respect than has existed under the systems which have been in use heretofore.

It is the writer's personal opinion, that simplicity should never be sacrificed in so grave a matter as giving indications for governing the runner of high speed trains, in order to give modifying instructions for slower speed movements. The time for correct action by the runner of a high speed train is so short that the message to be conveyed by signals must be so simple that its interpretation is intuitive and not the result of

reasoning. The message, therefore, must be limited to that which can be instantly comprehended by any one who can be expected to reach the position of runner and not by the highest, or even the average mental development to be found in runners as a class. It is the firm conviction of the writer that, taking into consideration all of the conditions surrounding the men whose duty it is to run an engine, the care of the machinery, the looking out for train order, block and interlocking signals, the graduation of power for grades and curves, taking water at speed, station stops, and a great many other exacting requirements, that the placing upon them of the responsibility of correctly interpreting a combination of signal indications which takes a variety of mental operations, is a long step away from safe practice. It would seem much safer to give the indications by one blade, which, if need be, can have four positions with corresponding night indications, four appearing to cover all present requirements, the blade pointing to the right of the signal mast as seen by an approaching train whose movement is to be governed by it.

(1) The blade in a horizontal position, red light at night.

(2) The blade vertically upward, green light at night.

(3) The blade inclined upward at an angle of 45 degrees, a red and green light at night.

(4) The blade inclined downward at an angle of 45 degrees, a yellow light at night.

The corresponding indications would then be as follows:

(1) Stop signal.

(2) Clear signal. Proceed. Next signal is also in position to be passed, being either clear or at caution.

(3) Caution signal. Proceed at such speed as will admit of stopping at next signal, which may be at stop or at caution.

(4) Caution signal. Proceed at such limited speed as is safe to take a diverging route from the main line from this junction or cross-over.

As discriminating between semaphores for interlocking and those for automatic block signals, there can be placed upon the mast a bracket projecting to the left, whose outer end shall have the same relation to the mast that the outer end of the semaphore casting has to the left of the mast for interlocked signals, and on the outer end of which a white light can be placed at night as a marker. For automatic block semaphores this bracket can be projected further to the left so that its outer end will appear to be materially further from the mast than is the semaphore casting upon that side and on the outer end of which a white light can be placed at night as a marker.

It is believed that such an arrangement of signals as this can be made to cover all of the necessary moves in territory where high speed is permitted and that in terminals or other points where the speed is necessarily limited, as compared with that on the open road, a dwarf signal indication can be given on the ground at the foot of or below the high speed signal to meet any adidtional requirements as to movements of trains at such points.

It will be seen from the above that the mental operations which the high speed runner would be obliged to carry out are limited to not more than four at the instant that he observes the signal, his rule being:

(1) Stop if a red light or a horizontal blade is displayed.

(2) Run if a green light or vertical blade is displayed.

(3) Reduce speed as is necessary if a red and green light is displayed, or the blade is pointing to 45 degrees upwardly.

(4) Reduce speed if a yellow light is displayed or the blade is pointing 45 degrees downward.

Having got his train under control, he then has ample time to consider further the movements which correspond with the kind of signal and with the location on the road. The diagram given herewith illustrates the system as proposed by the Railway Signal Association and that suggested by your reporter.

As a matter of information in connection with the use of interlocking and block signals in the United States, the following statement will prove most interesting.

During the last two years a wave of legislation has passed over the United States having for its aim the compulsory use of electric head lights on locomotives, and, although the railway managements presented the strongest arguments against such a requirement, many of the states passed the bill and made it a law.

There is no doubt but that the use of electric headlight largely diminishes the distinctive character of night indications of block and interlocked signals. On lines of single track the condition will be serious enough, but where there are two or more main running tracks the electric light blinds the runner of an approaching train on an adjoining track so that for an appreciable time after having met the train the eye cannot tell one colored light from another. It is a question still undetermined whether the continued repetition of this blinding effect will not seriously impair the vision and thus reduce the period of the runner's safe employment on lines where the highest speed trains are guided wholly by block and interlocked signals. While there is no chance for a repeal of this law for one or two years in those states where it has been adopted, it is hoped that other states will not follow their example and that experience will lead in due time to the elimination of this unfortunate and even dangerous legal requirement.

Summarizing the situation as regards interlocking in America: Application of power interlocking is rapidly increasing.

Electro-pneumatic and purely electric systems are superseding all other forms of power interlocking.

The track circuit, with electric locking, is superseding mechanical detector bars.

All forms of electric locking are being generally used in connection with heavily worked terminals and in heavy traffic territories.

Diagrams for facilitating the full utilization of tracks along passenger platforms are not used in the United States.

The Generation, Control and Transmission of Alternating Current for Railway Signals*

By Messrs. Frank Rhea and E. E. Kimball, General Electric Co.

The advantages of alternating current for track circuits have been more or less recognized for some time and papers have been read and publications issued outlining various systems of track circuits and details of A. C. signal apparatus, but the signal engineer is concerned with another problem, for, after he has his signal problem worked out satisfactorily, he has yet to obtain a reliable and constant supply of alternating current. As soon as he begins investigating alternating current generation and transmission, he finds that his direct current practice stands for little and that the laws governing alternating current are different from those governing direct current. For this reason it has been thought advisable to present an analogy between direct and alternating current generation and describe briefly some of the ways that alternating current can be produced, controlled and transmitted for the operation of railway signals.

It has been customary on steam railroads to obtain whatever electrical energy is required for the operation of signal apparatus from primary or secondary batteries placed at convenient locations along the line. In the case of storage batteries, limited means have been provided for charging them from a charging circuit along the right of way. In the direct current system, therefore, it will be seen that such electrical energy can be stored at various points along the road

*From the Journal of the Railway Signal Association.

RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

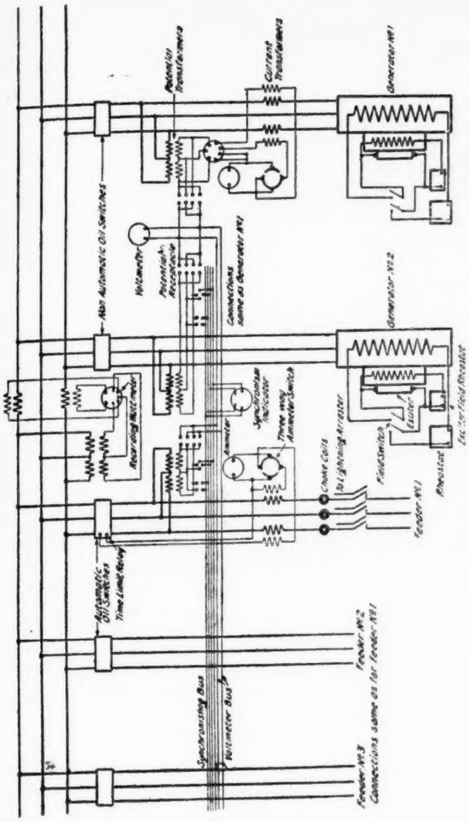


Fig. 1.

Typical switchboard wiring diagram for signal power stations generating power at the transmission voltage

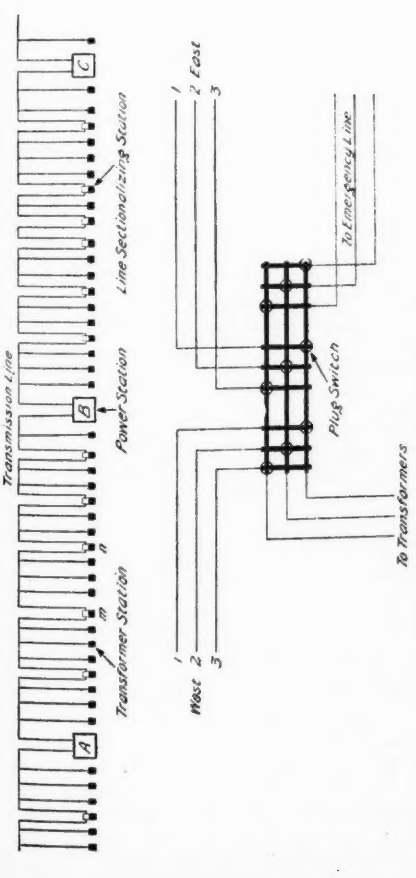


Fig. 2.

Transmission Line for A.C. Signals showing Method Proposed for Sectionalizing at Sectionalizing Stations

to operate signals for a considerable length of time without renewing batteries or recharging them.

Since alternating currents cannot be generated by chemical action as in a primary battery, or stored as direct current can be, it is important to consider how such currents are generated. Alternating currents possess certain valuable characteristics on account of which it is possible to transmit energy long distances with little loss of power, whereas, in the direct current system the distances are necessarily short on account of the expense involved and the poor efficiency.

Illustrating one of the valuable characteristics of alternating currents, it is possible to reduce the line losses by stepping up the voltage at the generating end and stepping it down again at the receiving end. This operation involves only static transformers which are very efficient.

These are, however, not the only ways in which alternating current varies from direct current. For instance, with direct current it is only necessary to know the voltage and current to determine the power, whereas, with alternating current these are not sufficient, but in addition it is necessary to know the number of phases and the power-factor, and to fully identify a system it is also necessary to know the frequency, that is, the number of alternations per second.

A direct current generator consists of a bundle of wires wound in slots in an iron core called the armature, which revolves before powerful electro-magnets called the field. The ends of the armature windings are fastened to bars in the commutator which travel under carbon brushes the function of which are to collect the current before it has a chance to reverse its direction, for as soon as a coil passes under a brush the current in that coil reverses on account of passing by a south pole instead of by a north pole. If instead of bringing out the ends of every coil to segments in the commutator, all the coils are connected in series around the circumference of the armature and two taps at opposite ends of a diameter are brought out to two collector rings, the machine would generate alternating current instead of direct current. In this case since there is but one external circuit the alternating current generated is called single-phase. If three equi-distant taps are brought out to three collector rings the alternating current generated is called three-phase since there are three external circuits. If four equi-distant taps are brought out to four collector rings the current generated is called quarter phase or two-phase.

Taking the three-phase generator as described above, it should be noted that since there are the same number of armature turns between each tap, the voltages between any two circuits will be the same. This should not be confused with the three-wire system in use for lighting systems, where the voltage between the outside wires is twice the voltage between the center and either outside wire. In a perfectly balanced three-wire lighting system the middle wire carries no current. In a perfectly balanced three-phase system each wire carries the same amount of current.

Suppose a direct current generator runs normally about 500 r. p. m. If it then be run at 1,000 r. p. m. the voltage generated will be about twice that generated at 500 r. p. m. In the case of an alternating current generator the voltage at 1,000 r. p. m. will also be twice that at 500 r. p. m. and the frequency will be twice that at 500 r. p. m. Frequency is usually spoken of in cycles per second or alternations per second. A cycle for a 2-pole generator is one complete revolution, for a 4-pole generator it is one-half a revolution, for a 6-pole generator it is one-third of a revolution, etc., etc. In each revolution of a 2-pole generator there are two alternations, hence a cycle consists of two alternations. It is convenient to remember the following rule in regard to frequency:

"The frequency of any generator is equal to the number of revolutions per minute, times one-half the number of poles, divided by sixty."

It is desirable at this point to compare two or more D. C. generators operating in parallel and two or more A. C. generators operating in parallel. With two direct current generators of the same design running at the same speed and the same voltage, it is possible to connect them in multiple and each will take its share of the load. If it is desired that one generator take more load than the other it is only necessary to raise its voltage; in fact, it is possible to make one machine take all the load and run the other as a motor merely by varying the potential sufficiently. It is not necessary to have the two machines running at the same speed provided the voltages are equal before throwing the paralleling switch, and they will divide the load equally between them.

In the case of two alternators of the same design it is not only necessary that the machines be running at the same speed and the same voltage before they are thrown in parallel, but it is necessary that the paralleling switch be thrown at the instant when both machines are in phase, they then act as if connected by gears, if one runs faster the other also runs faster. Varying the voltage after the machines have been phased-in will have no effect on dividing the load between the two machines. The only way that the load can be adjusted between the two alternators is by opening or closing the throttle on the prime mover. Adjusting the field rheostats to change the voltage of either machine only changes the amount of current which flows between them but does not affect the current in the outgoing line, except possibly in line losses and in change of load due to variation of line voltage. This current which circulates between the machines is called "wattless" or "idle" current as it does no work.

Since there is a possibility of having idle currents in an alternating current circuit it is necessary to introduce a factor by which the product of the volts and amperes (the apparent power) must be multiplied to give the real power. The apparent power in a single-phase line is equal to the product of the volts and amperes, the apparent power in a balanced three-phase line is equal to the product of the volts and amperes, times the square root of three. A quarter-phase circuit is the same as two independent single-phase circuits. The real power is the apparent power multiplied by the power-factor which is never greater than 100 per cent.

The real power is measured by a watt-meter. This instrument can be supplemented by a wattless component meter if necessary.

A. C. System.

The alternating current system of signaling here discussed consists briefly of a number of power stations or sub-stations along the right of way, connected by transmission wires. These transmission wires supply current to small step-down transformers every block for track circuits, for operating signal apparatus and for lighting the signals if so required. As often as desired and for intervals not over five miles the transmission line is sectionalized so that any section may be cut out. The line is also sectionalized at every power station or sub-station, making it possible to feed in either direction, or both, from any station. For illustration, station A, Fig. 2, may feed to the right and to the left. In case of a failure between m and n, A can feed to m and B to n, leaving the line dead between m and n. The apparatus should be designed liberal enough to permit feeding the entire line from sub-station B, should it be necessary to shut down either A or C, or both.

Power Stations.

The location of power plants for a proposed installation of railway signals will, of course, largely depend upon that particular part of the line under construction. In general, however, it is proposed to locate them at points where there is already a demand for power, at round houses, repair shops and at water stations, thus combining under the direct charge of one attendant such joint power plants. These stations can be placed 20—40 miles apart, denpending upon the voltage employed and the particular requirements of the service. On account of the flexibility of the alternating current system considerable latitude is allowed in the location of these stations, thus permitting the use of existing power plants to the best advantage. It is important to consider the source of power at these stations in order to discuss the types of apparatus available and the adaptability of each for signal service.

Signal power plants can be either independent power stations or sub-stations, that is, they can consist of prime movers or converters. The latter class have a greater application on electric than on steam railroads, since a main power station and a high tension transmission line are usually available. They are discussed here because it is sometimes necessary to buy power from a local power station for the operation of motor driven pumps, for machine tools or for lighting, and if it is convenient to locate a signal station at the same point, means can be provided for adapting the power to the signal system without the expense of building an independent power plant.

Prime Movers.

Power stations will either consist of direct connected steam engines or steam turbine units, or direct connected gas engines. Belted, geared or chain driven units are considered less suitable for signal service mainly on account of the introduction of another link in the transmission, greater maintenance charges and less reliability. These latter units are generally less expensive than the direct connected units, for which reason they may require consideration for some installations, but need not be discussed here.

It was seen in the early part of this paper that for alternating current generation the speed of the prime mover was an important factor and if commercial frequencies are adhered to for signal service, all generating apparatus will run at certain definite speeds, which are given in table below, and the speeds of the prime movers must be adapted to the speeds of the generators.

TABLE I.

Synchronous Speed of 25 and 60-cycle Motors and Generators.

No. of Poles.	25 cycles.	60 cycles.
2	1500	3600
4	750	1800
6	500	1200
8	375	900
10	300	720
12	250	600
14	214	514
16		450
18		400

Alternating current generators and motors of small capacities are manufactured with a fewer number of poles and the number of poles increases as the size of the unit increases, consequently the speeds of the small machines for the same frequency is greater than that of the large machines. The following table shows the speeds of steam engines, steam turbines and gas engines which conform to best practice.

TABLE II.

Economical Speeds for Engines—Turbines and Motor Generator Sets of Various Capacities.

K. W. Capacity.	Steam Engines.	Gas Engines.	Turbines.	Motor Gen. Sets.
5- 10	450-600	700-750	5000	1200-1800
10- 20	350-450	650-700	4500	900-1200
20-50	350-450	550-600	3600	900-1200
50-100	300-400	400-450	3000	720- 900
100-300			1500-1800	720- 750
300-500			1500-1800	720- 750

Comparing this table with the previous one for alternating current generators, it will be seen that for small sizes the steam turbine is not adapted for alternating current service on account of its high speed. We can, therefore, assume that for the ordinary and smaller stations the prime movers in signal power stations will be either steam or internal combustion engines.

Direct connected steam engines of the marine type are manufactured for direct current purposes in sizes suitable for direct connection to alternators. Internal combustion engines are now built in commercial sizes suitable for operating alternating current generators. The choice between these types of prime movers will necessarily be governed by adaptability, first cost, cost of maintenance, etc. The reliability feature is more or less a question of prejudice for or against one type or the other. It is recommended that internal combustion engines be four stroke cycle with four or more cylinders.

Alternating Current Generators.

There is also offered two types of alternators, namely, the revolving armature and the revolving field type. In the former type the alternating current, either single-phase or three-phase, is collected from slip rings, as explained in the introduction. On account of the difficulty of insulating the collector rings and brushes these machines are limited to low voltage generation. On the other hand the revolving field type requires no collector rings (except for the D. C. exciting current which is always low voltage) consequently, they can be wound for any voltage up to 6600 or 11,000 volts. Either type of generator can be furnished with direct connected exciter. For signal purposes the revolving field type of generator is recommended on account of the superior construction and better insulation afforded.

Converters.

If electrical energy is available at points along the line where it is advantageous to place signal stations, sufficient energy can be converted into alternating current of the proper frequency by one or more types of converters as enumerated below.

Direct current motor generator sets consist of two units mounted on the same base and direct connected, the motor is driven by direct current from the source of power and drives an alternator, thus converting direct current, so to speak, into alternating current.

Motor generator sets consisting of two alternating current machines of different frequencies are called frequency changer sets. They consist of an alternating current motor called a synchronous motor, and an alternating current generator. Thus it will be seen that the signal frequency need not be the same as the power frequency. The voltage of such a generator is in no way dependent upon the voltage of the motor.

Transformers.

When the frequency of the power load is the same as that of the signal system, but the voltage different, only transformers are required to adapt the power to the signal system. In some cases where the units are small it has been found advisable to generate power at low voltage and step it up to a higher voltage for the transmission line, but when the units are large enough to permit winding them for the transmission voltage it simplifies the station arrangement considerably to do so.

Switchboards.

The switchboards in signal power stations will, in general, control two or more generating units and two or more transmission lines or feeders. In the control of these circuits it is important that the switchboard be as flexible in its operations as possible, but without introducing undue complications.

The following operations have been considered important:

Ability to substitute generators without cutting off power.

Ability to make emergency connections quickly, safely and without errors.

Ability to run in parallel with stations on either side, or to connect the transmission lines through giving the operator an opportunity to shut down the whole station without interrupting the signal service.

Ability to operate a temporary or emergency line while signals are being re-located, or while making repairs on the permanent line.

The general scheme here proposed is to have a common bus with branch circuits to the generators and outgoing lines, each circuit being controlled by a switch. These switches can be either hand operated or automatic, that is, they can be arranged to automatically open the circuit in case of an overload, or without this feature.

The automatic switches may be equipped with either a time limit relay or with a series trip. The time limit feature prevents the switches opening with every momentary overload, which would cause considerable annoyance, but only opens when the overload is sustained such a period as may become injurious to the apparatus. It is not necessary to have the automatic feature on every switch, since the system can be fully protected by automatic switches at points where a warning bell can be sounded and the attention of the operator called to the fact that the switch has opened. In general automatic switches with time limit relays and bell signal device should be supplied with every feeder panel. Generator panels should have non-automatic switches.

In considering oil switches for signal power stations, it is necessary to consider only those which are suitable for operation on a maximum voltage of 6,600 volts, since the power required for the signals is small, and a higher potential will not permit enough saving in copper to offset the additional cost of transformers and better insulation. With this limit in voltage and the amount of power transmitted, oil switches of small dimensions and compact designs can be mounted directly behind the panel or on a framework which requires very little space.

All oil switches are quick break, that is, the moving contacts drop away from the stationary contacts rapidly when the switch is opened.

Air brake switches are not recommended for alternating current circuits except for disconnecting switches, since the voltages are usually high enough to carry the arc from one blade to the next when the circuit is opened.

The connections for the following instruments are shown in Fig. 1.

A voltmeter, usually mounted on swinging bracket and wired to two or more 8-point potential receptacles, so that the voltage of any phase of any generator may be read.

An ammeter on each generator panel, so that current in any line may be determined.

An indicating wattmeter on each generator panel.

A recording wattmeter in the bus.

A synchronism indicator and on every generator and feeder panel two 4-point synchronizing receptacles, to enable phasing in with any station or any generator.

Potential and current transformers, field rheostats and switches, lightning arresters and disconnecting switches and ground detectors are shown where necessary.

Transmission Lines.

The transmission lines may be run underground or overhead as local conditions demand. It is, of course, better protected from damage by wrecks, sleet storms and lightning troubles if placed underground than if placed overhead, but the cost of laying conduit and suitably insulating the conductors has thus far prohibited extensive underground construction for railway signal purposes. On the other hand, thousands of miles of pole and tower transmission line construction have been operated by power companies throughout the country with only slight annoyance from sleet storms and lightning.

The most serious mechanical failures are caused by sleet collecting on the wires, followed by cold weather and high winds. This condition occasionally takes down several miles of transmission line unless liberal allowances are made in selecting the size of wire, pole spacing, amount of sag, insulators, insulator pins and cross arms. In some installations it will no doubt be satisfactory to place the transmission line on the same poles with the telegraph and telephone wires, but under present conditions there are few pole lines constructed and maintained in such a manner as will warrant placing the signal transmission lines on them.

There are two or more ways to provide against mechanical failure of a transmission line seriously affecting the operation of the signal system, namely, by constructing two independent transmission pole lines or by sectionalizing, or by a combination of the two. Possibly the latter is the best, but the cost of so doing will limit this application to only the larger and more important installations.

A very satisfactory and safe form of transmission at a reasonable expense can be provided by using a lead covered cable carried on existing pole lines supported by messenger wire construction. The lead sheath should be grounded at intervals. By adding intermediate stub poles this construction can actually be made very reliable, although not of entirely pleasing appearance.

However, the most desirable arrangement is underground construction, preferably pull-in type of conduit. This form of construction is, as a rule, prohibitively expensive for most signal installations. It is the opinions of the writers that an entirely practical and very durable type of construction can be devised by what we would term lay-in construction, using as a form either a special clay product or treated timber trunking, after cable is in place protecting same by filling form with some plastic insulating compound. For such construction providing a covering and in addition under streets and public roads protecting by a layer of concrete; in fact, protecting the entire length of the transmission system in this manner would be of advantage. If lead covered conductors are used precaution should be taken to protect them from salts in the cement covering, and if treated timber trunking is used, it is very necessary to keep any rubber covered wires coming in contact with the preserving oils.

It is also felt where transmission wires are of sufficient size (No. 8 B. & S., or larger) that the use of varnish cambric insulation is permissible without sacrificing in the least reliability or durability and at a saving of approximately 25 per cent for the cost of conductors.

A method of sectionalizing a signal transmission line is shown in Fig. 2.

The method of sectionalizing is briefly as follows: On the busses and one horizontal bus; east line is connected to one back of a slate or marble panel are mounted three vertical vertical bus, the west line to the middle and the emergency line to the third bus. The transformers are located in the lower compartment and are conected to the horizontal bus. It is proposed to connect the vertical bus with any of the horizontal busses by means of high potential plugs in the manner shown.

Lightning Protection.

Lightning protection consists in providing means for allowing lightning to pass to ground without going through transformers or other apparatus on the line and at the same time prevents the line current from following after the disturbance has passed. There are two general types of arresters on the market at present, namely, electrolytic type and multi-gap type of arresters. The electrolytic type has many advantages which render it better adapted for high voltages and large capacities than the multi-gap type. These advantages lie chiefly in the ability to set them for a discharge voltage only slightly in excess of the operating voltage. This type has also a larger discharge capacity.

The multi-gap type is smaller, less expensive, requires less attention, and for this class of service will give sufficient protection if properly located and a sufficient number used.

Three-Phase vs. Single-Phase.

It seems advisable at this time to call attention to some of the features of three-phase and single-phase apparatus which make the three-phase distribution preferable to single-phase. Single-phase induction motors in themselves are not self-starting. Phase-splitting devices or single-phase commutator motors are required for the operation of the signal mechanism. On account of the energy consumption and the limited space afforded for these phase-splitting devices, it is frequently necessary to compromise in their design, with the result that they frequently give trouble from burn-outs.

Most of these methods of phase-splitting involve some complications in the wiring which in a measure offset the extra connections required by the third wire in a three-phase distribution system. Even with the phase-splitting devices used on single-phase motors the torque is inferior to that obtained by three-phase or quarter-phase motors. Three-phase generators operate better in multiple because they are held in step better than single-phase generators. Three-phase transmission lines require less copper for the same efficiency than single-phase transmission lines.

In case of single-phase transmission the failure of one wire or one transformer cuts off the entire supply of power. A failure of one wire or one transformer in a three-phase distribution system leaves a single-phase with phase-splitting devices in circuit, so that if the line is properly insulated the apparatus on the line will receive power and will be able to continue in operation until trouble is remedied.

Single-phase generators require more material, and, consequently, cost more than three-phase generators and at the same time have poorer regulation.

As seen above, the current required to operate single-phase motors is excessive, and it is obvious that a greater difficulty will be experienced in obtaining a generator of sufficient capacity and regulation to supply current for clearing all signals after an interruption of power.

Parallel Operation of Signal Power Stations.

In the parallel operation of signal power stations much depends upon the size of units employed and the size of the transmission line. For instance, a large station with large units may keep a smaller one in step over a light transmission line, but if it is desired to operate two large units each with an external load three or four times the signal load,

then the transmission line would not be large enough to hold them together, as the resistance of the line would not allow sufficient synchronizing current to flow back and forth over the line. It is, therefore, felt that it will be found entirely practicable with alternators in the several stations of sufficient size to supply only the amount of current required for the signal system, or even with one large power plant to operate three or may be four power stations in multiple, each station pumping into the line its share of the power in much the same way that air pumping plants operate in electro-pneumatic systems.

Before leaving the transmission line it is important that the signal engineers keep in mind and work towards adopting standard voltages in order to avail themselves of the development of standard apparatus insofar as it meets their requirements as well as would any other unusual voltage.

Conclusion.

In conclusion, we feel warranted in making the statement that by utilizing the best available apparatus, by following the most approved methods of construction and by proper study of the environments of each installation, that transmission systems can be constructed that will be found entirely adequate and reliable to furnish the necessary current to meet the exacting conditions of railway signal service. We venture the prediction that the use of A. C. current will be extended in future signal installations on account of its being the only absolutely effective means of eliminating foreign current troubles and it is practical to so design and construct A. C. signal apparatus which will be found more reliable and robust than D. C. signal apparatus. There is also the great advantage in the transmission of alternating current over direct current.

Subaqueous Concrete Work

By H. R. Lordly, M. Can. Soc. C. E.

The primary object of this paper is to describe the rather extensive concrete work in connection with the Quebec canal system, and more particularly the construction of five miles of concrete wall without unwatering on the Lachine canal.

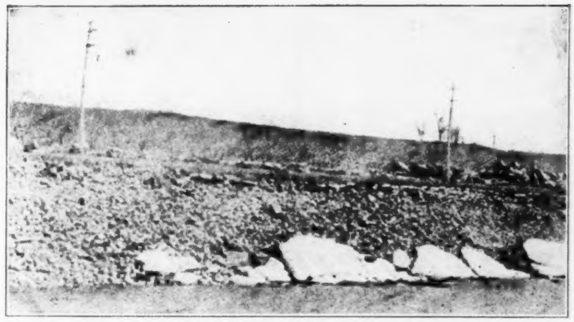
"Engineering News," November 25th, 1909, states editorially that "there is undoubtedly a strong prejudice in the engineering profession against laying concrete under water. Millions of dollars are spent every year on coffer-dams and caissons, in order to lay foundation concrete in the dry. Notwithstanding this, it is entirely possible to lay concrete under water which will be as sound and solid as the best concrete laid in the open air."

The article then recites, as one example, the construction of the Detroit tunnel, and while there are doubtless many minor undertakings of subaqueous concrete work, it is quite probable that the lack of published articles on the subject is due mainly to the fact that engineers actively engaged in construction work are not usually in a position to write up their experiences, at least during the progress of the work.

The author has in his possession notes on concrete construction under water, dating back many years, and giving various methods employed abroad, particularly on lighthouse and jetty work in Great Britain. Many of the older methods were confined to the use of paper bags, sacks, etc., to provide an additional safeguard against washing out.

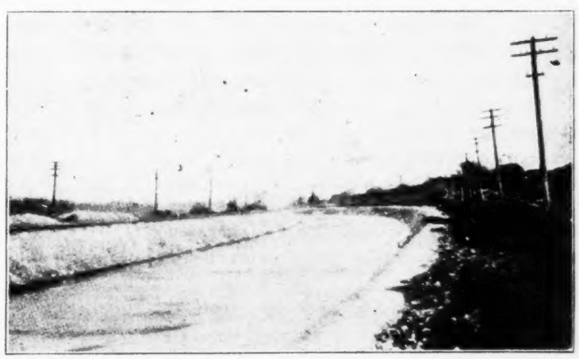
A leading United States cement manufacturing company, in a pamphlet on "Concrete Construction," gives a warning, as follows:

"Concrete should never be placed under water if it possibly can be avoided, because the materials are in danger of separating. The danger of the fine material separating from

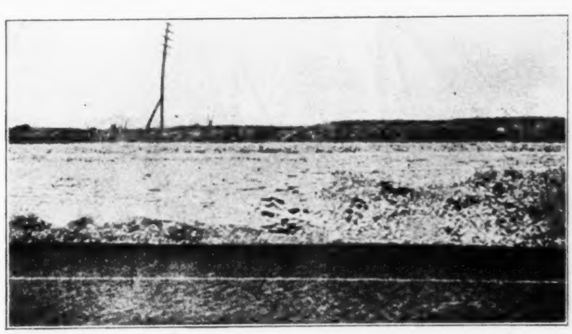


Old Riprap Wall Showing Effects of Ice.

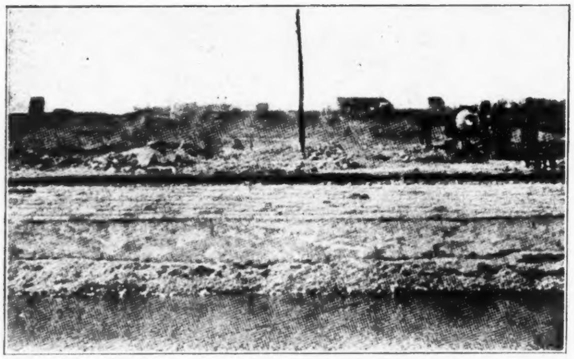
Section of Canal Before Placing Concrete Facing.



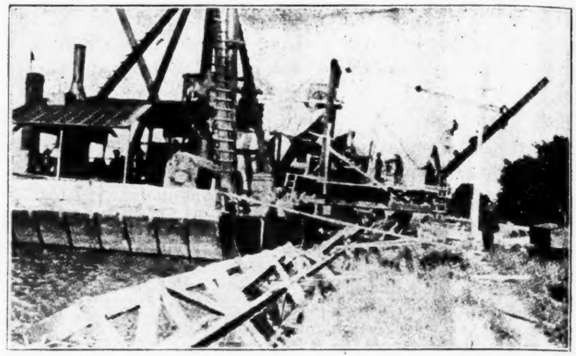
Same Section as Above After Placing Concrete Facing.



Heavy Dry Masonry and Riprap Injured by Derrick Spud.



Concrete Belt Wall Over Rock, Dry Masonry on Top.



Mould in Position, Mixing Plant at Work.

the coarse was illustrated in a little test by the engineers constructing the Holyoke dam.

"A small batch of concrete was mixed in the proportion of one part of cement to two and one-quarter parts sand to five parts stone, and thrown into a pail of water with a trowel. The surface hardened satisfactorily and, after several months, the water was poured off and the material taken out. Instead of a uniformly mixed concrete, three layers were found. On top was a thin layer of practically neat cement, then about two or three inches of mixed sand and cement in a porous mortar, then below this a mixture of sand and stone as separate and clean as before the concrete was mixed.

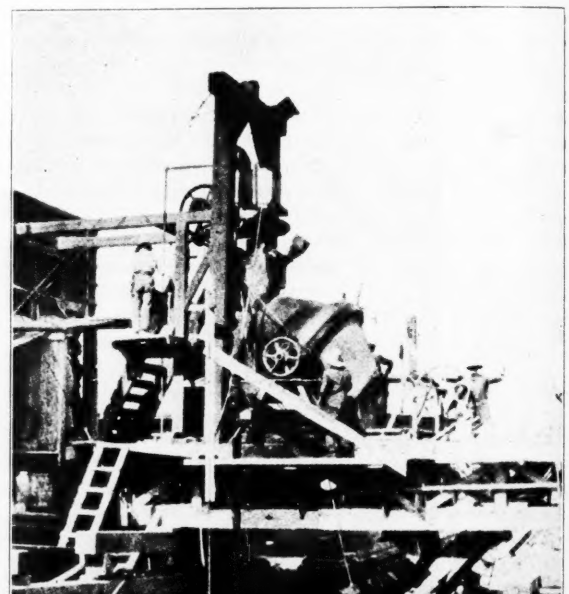
"This experiment and other tests show that if concrete has to be placed under water it must be deposited in large masses, and never by shovelfuls.

"On small work, put the concrete in pails, place a board over the top of the pail, and lower it carefully into the water to the bottom. Turn the pail upside down, carefuly remove the board, and slowly raise the pail, allowing the concrete to flow out. Great care must be taken not to disturb the water in which the concrete is being placed, nor to touch the green concrete. Concrete must never be placed under water if there is any current, because the cement will be washed away, leaving only the sand and stone.

"Another method for depositing concrete under water is to pass the concrete slowly through a sprout or tube which reaches to within a couple of inches of the bottom where the concrete is to be placed. The tube must be kept full and the concrete kept moving continuously and slowly through it. On large work, specially designed buckets are used for depositing the concrete under water, but these are generally operated by a derrick."

This warning may be necessary from the standpoint of a cement company which desires to see its product respected, and the advice "not to deposit by shovelfuls is good," but the scare clause, "concrete should never be placed under water if it possibly can be avoided," is somewhat out of place in these days of progressive engineering.

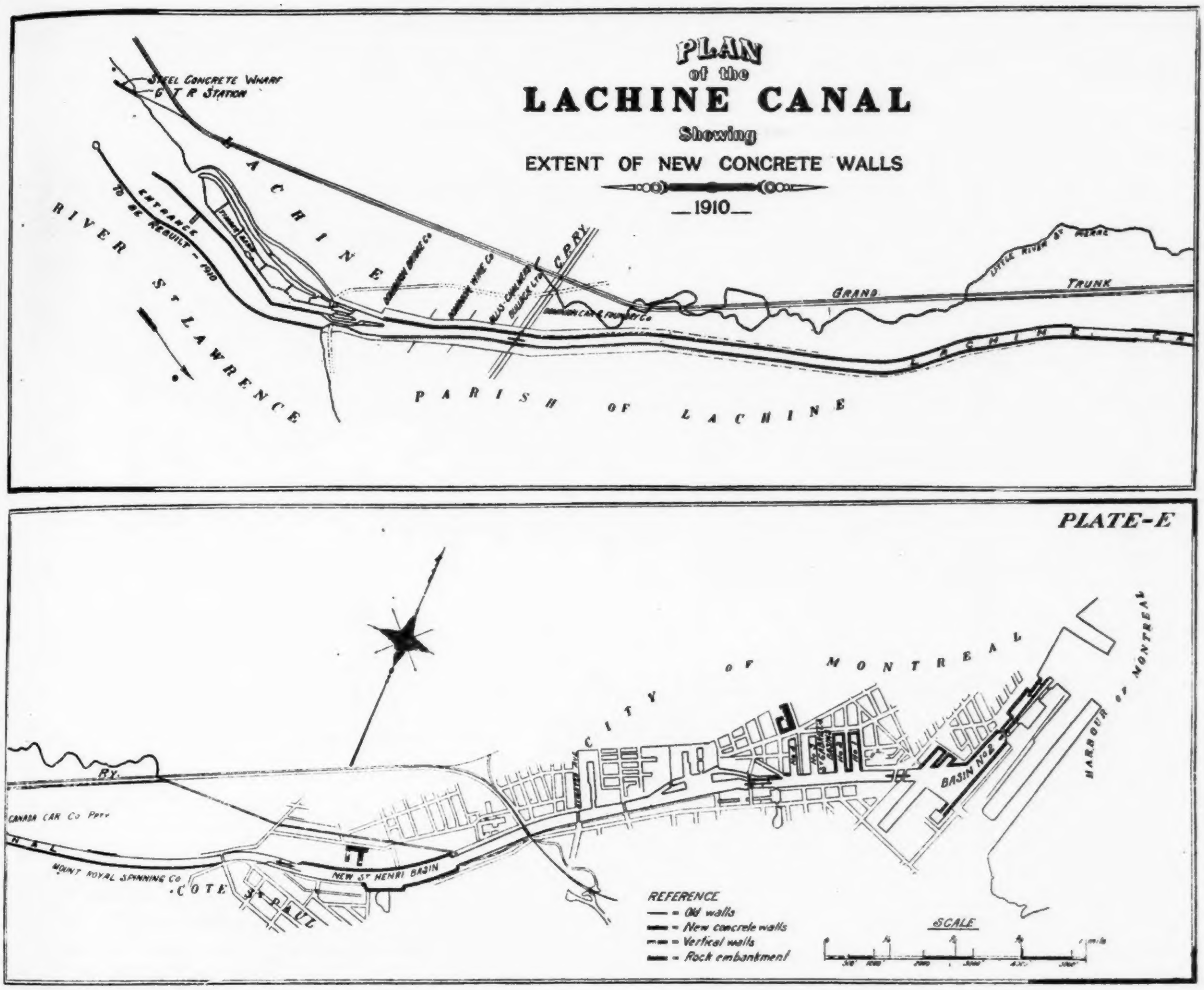
Lifting 100 Ft. Mould for Concrete Facing.



Concrete Mixing Plant, Showing Bucket, Arm, Mould and Blocking.

Necessity demands, at times, that concrete be placed even where there is a current, and the author believes, after an experience of handling sixty thousand cubic yards of concrete in subaqueous work, that the "specially designed buckets for depositing the concrete under water" are sometimes unnecessary.

It is rather a pity that such a trivial experiment, as quoted



above, should be seriously offered as a reason for rejecting such an important material of construction.

The carrying out, however, of subaqueous concrete work really depends on whether the special method which it necessitates makes the work more costly than doing it in the dry, or if, under the circumstances, there is no other alternative.

In the case to be described here, the slope walls of the Lachine canal, the alternative had been tried and had failed to meet the requirements.

Before directly entering on the subject proper of this paper, it will be well to review briefly canal slope-wall construction, and particularly the conditions on the Lachine canal which gave rise to the necessity of subaqueous work.

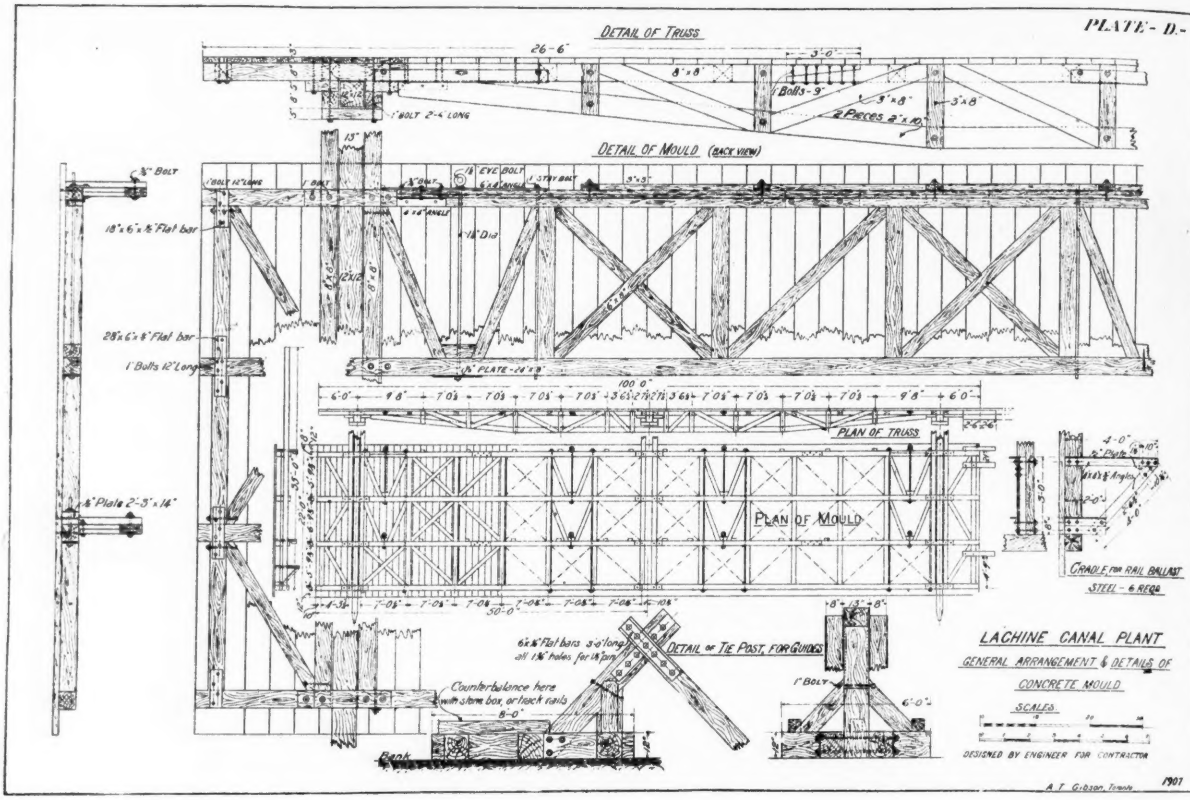
This historic waterway, in its various stages of enlargement, the construction and reconstruction of its prism walls, affords much information that may be useful in many branches of hydraulic work. It also proves one important point, viz., that, with modern sized vessels (see illustrations), more powerful propulsion, and a greater requisite speed, earth embankments and small rip-rap must give way to concrete, and that in established waterways, where repairs must be made without unwatering, this new method of lining can be applied effectively and economically without interfering with navigation.

In the report of the International Waterways Commission, 1898, various methods of constructing canal embankments are discussed, but it is doubtful if, outside of the pitched stone, or rip-rap, used on the banks of the Manchester ship canal, any of the other methods described, such as earth embankments, with or without bermes, etc., would be of value on our Canadian canals, at least on those of the standard size. In this connection it must be noted that a canal which has to be unwatered for short periods in the spring of each year, and which has earth embankments covered with light rip-rap, is likely to have these slide in and cause much damage. In this respect, ice is also a factor which must be considered (see illustrations).

One engineer, quoted in the above report, stated that a test had been made on a German canal with a lining of sand beton. Small slabs were moulded in boxes, and, when set hard enough, were placed in the wall. This plan was afterwards given up and the blocks moulded on the banks, the thickness of the covering being about six inches. The proportions of the beton were one to ten, and it was only used at levels below water-line. The mixture was found too lean to be of value when exposed to the air.

On some French and Italian canals a covering of beton, made with hydraulic lime, has been used. On canals of very small cross-section an attempt at waterproofing this beton has been made by covering it with "chape," a mortar of Portland cement. All of this work has been done in the dry.

It would appear that the construction of heavy concrete slope-walls in canals of the larger size, and particularly by a subaqueous process, has been first carried out in Canada,



and the experience gained here should prove of value. Vertical walls are also being built under water in the same manner.

Plate A shows sections of the various enlargements and deepenings of the Lachine canal. No. 3 shows the section when, during period from 1840 to 1870, the canal had a navigable depth of only nine feet. The dotted line represents a section of the Manchester ship canal.

No. 4 represents the section after the year 1870, and it is during this period that the question of slope-wall construction became an important one. Types 1, 2, 3 and 4 show the various kinds of projection used for the face of the slopes.

Originally the slope-walls were rip-rapped, or pitched, as it is termed in England, largely with the stone excavated from the work. Some of this stone, which was of the nature of a dark shale, disintegrated, and under the increased wave action, due to steam towage and steam-propelled vessels, large areas of the walls were destroyed. One of the illustrations shows the condition of some of the walls in the spring of 1897, just previous to the deepening of the upper reach in that year. This is type 4 in the plate. See also the illustrations following.

In 1898 it was decided to rebuild the damaged wall in heavy courses with crystalline grey limestone from the Caughnawaga quarries. The base of the new wall was about three feet thick, and the courses decreased one inch per foot of slope.

Above the water-line was a coping course, and on top of this a revetment of broken stone was placed, to take the wash of the steamers (Plate A, type 1).

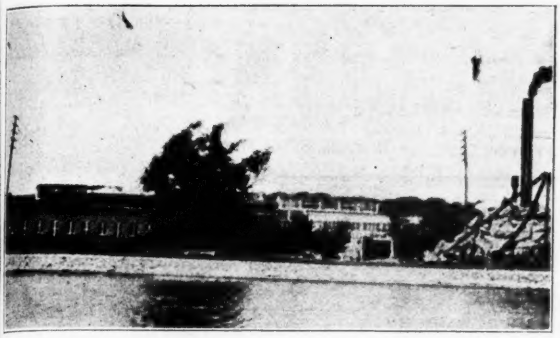
This work was carried on for a number of seasons during the period of unwatering, in the month of April. As there were upwards of seven miles of wall to rebuild, and the progress made by working only two or three weeks each year could not be otherwise than slow, it was seen that some other method must be adopted in order to hasten the protection of the banks.

In 1904 the author, who was then in charge of the work, was instructed to prepare plans for rebuilding the walls in a more expeditious manner. The superintending engineer of the Quebec Canal Division, Mr. E. Marceau, approved of using concrete on the slope-walls, and this material had already been very largely used in rebuilding the locks and the vertical walls at the entrance to the canal. By the use of concrete much skilled and expensive labor could be dispensed with; stone cutters were difficult to get and harder to hold, particularly in the early spring time.

The face of the slope-wall is about 24 feet (slope 1 to 1). It was first decided to use a belt of concrete, 8 to 12 feet wide and 1 foot thick. This belt was to be placed in the middle section of the wall, leaving in any rip-rap below which was in good condition, and running the concrete all the way down in a column, 4 feet wide, to a firm foundation, at points about 24 feet centers. (See sketch, Plate F.)

From the 16-foot level, up, the ordinary limestone rip-rap, as originally designed, was to be used. With this plan of doing the work it seemed possible to provide for a considerable length of the concrete belt being placed rigidly, so as to permit the stonelayers to finish the work by the first of May, when the water was run into the canal, and also to have portions of the old rip-rap that were firm. The work was generally started by April 3rd or 4th, but usually it was difficult to get more than three good working weeks.

In the execution of this plan some difficulty was found in using mould boards for the face. They proved difficult to keep in place, and more expensive to handle than was anticipated. In some portions of the wall an attempt was made to use a stiffer concrete, about one foot thick, laid on without any forms, but this proved too slow. About a quarter of a mile was done in three weeks, although, as will be seen in the photograph herewith, the rocky bottom of this

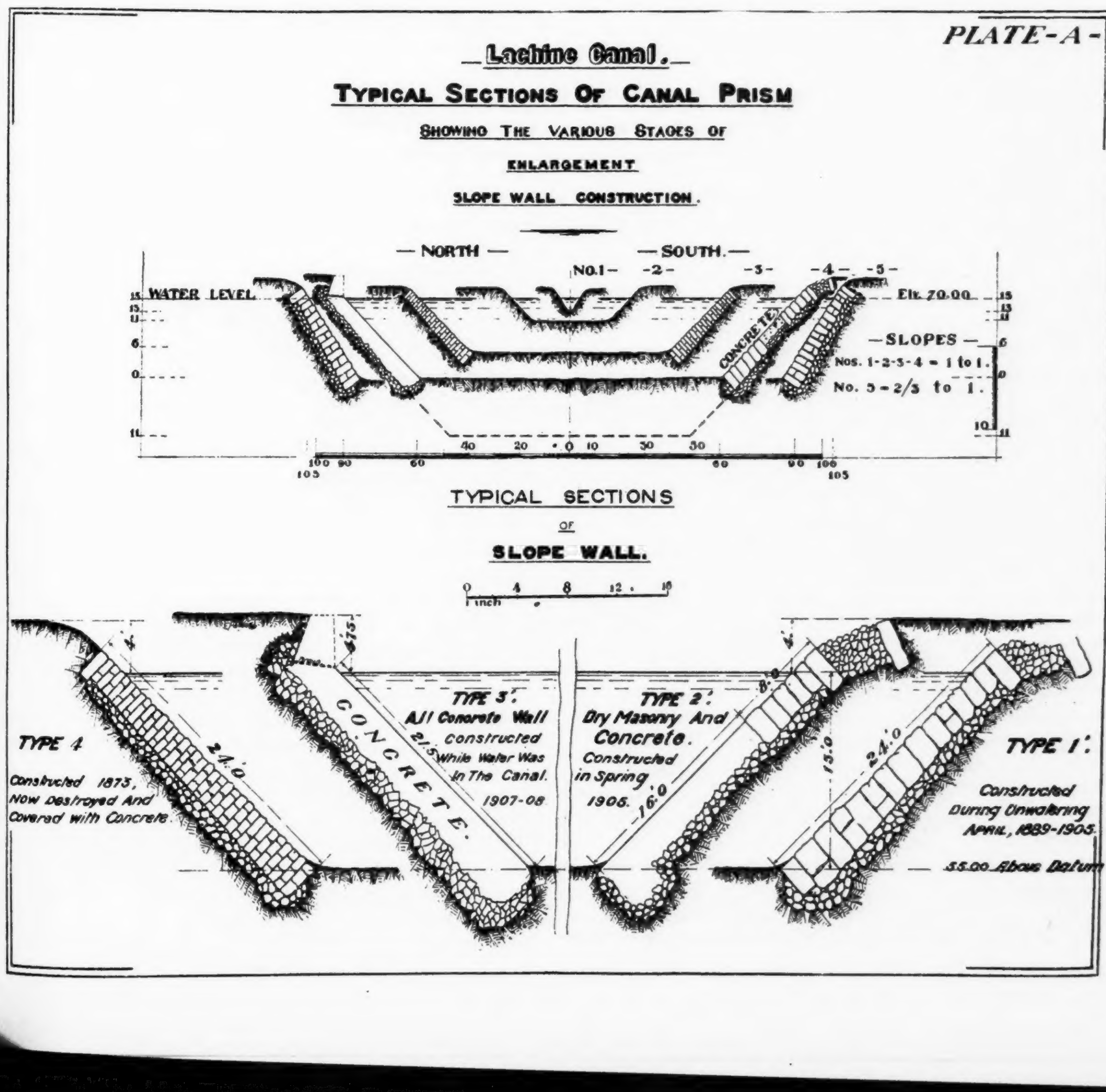


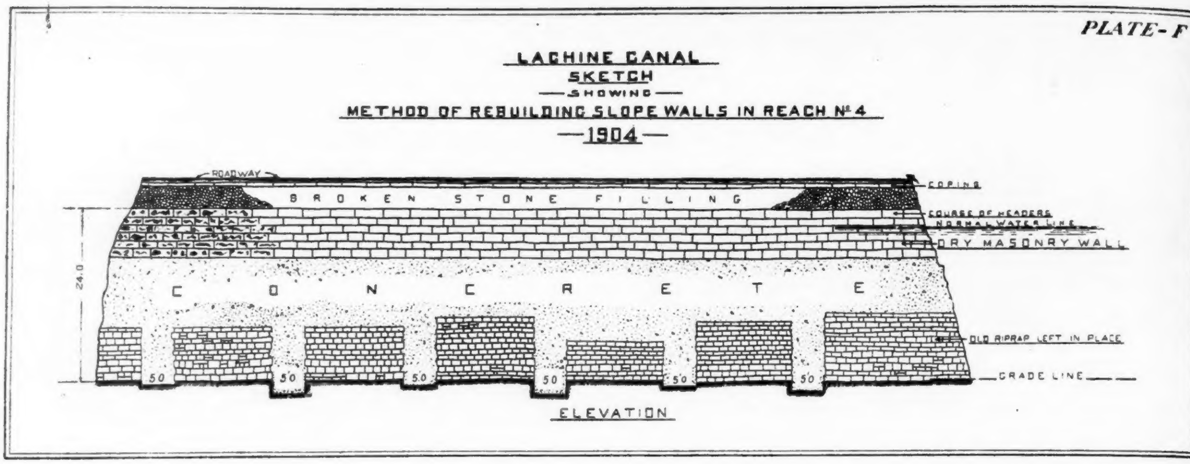
Revertment Wall Over Concrete Wall.

particular portion of the canal did not require as much concrete as would be called for in other sections. This method gave a higher class of wall, and more of it in a limited time. By it also the cost of labor was reduced, thus offsetting to some extent the extra cost for cement. A section of the concrete belt wall will be seen in Plate 1, type 2, and a photograph, showing the finished revetment above water-line, is also given.

The wall on the south side of the canal, upper reach, was steadily getting worse, and on the north side a number of leaks were in evidence. The method of doing the work in the dry had proved too slow, and some more rapid system had to be devised. It was then proposed that the walls should be laid entirely in concrete, except the revetment, and that the whole work should be done without unwatering the canal and during the period of navigation.

Under-water-concrete work had already been done in some minor cases on the canal, and one experience, that of the abutments on Black's bridge, was taken as suggesting the possibility of successful subaqueous construction of the slope walls. In the spring of 1903, during the building of the north abutment of this bridge, just after the forms had been placed, the water in the river rose rapidly, until there was a depth of 23 feet over the foundation. Time did not permit of waiting for the water to recede. At first a wooden chute was used and the concrete dropped through it, but after one corner of the forms had been filled, the box was discarded, and the concrete was dumped from barrows directly on the edge of the filled portion and allowed to flow forward at its own natural slope. The slow movement of the concrete was the best guarantee against washing out of the cement. The water was cold, and the set retarded sufficiently to aid the work in preventing injury to the placed concrete while the successive batches were dumped on the top of the sloping mass in situ. There was no current in the canal, but, on account of the rise and fall of the water in the river, a slight undulating movement was experienced. This abutment, which had a width of from 14 to 8 feet, and a total length of 80 feet, was thus satisfactorily completed in time. The





face of the wall, when the forms were removed, was found smooth and in perfect condition.

In lining the prism walls below water with concrete a different problem arose. Navigation was to be maintained: the current in the canal of about one mile per hour and the wash of passing vessels had to be provided for. The face of the wall is 24 feet, slope 1 to 1. The thickness of concrete required 18 inches, and, as mould boards would have to be used, there was a danger of the concrete clogging between the form and the projections of the old masonry wall, thus creating large voids. A method of preventing the clogging and forcing the concrete down in place had to be devised.

After some preliminary discussion, the contractors for the original work, Messrs. Haney, Miller, Quinlan & Robertson, came forward with an offer to do the work under the conditions described, and agreed to build the following plant: Six moulds, or forms, 100 feet by 24 feet face; a mixing plant, with a ram and box that would carry the concrete down between the wall and the forms; a lifting scow; a diving plant, etc., etc. The plant was calculated to do 200 yards per day.

It was proposed to prepare the toe of the walls during the spring unwatering. The forms were to be floated to the work, during the period of navigation, placed by the aid of the lifting scow and divers, and heavily loaded at the bottom to remain in position. Each form would be kept in place until the concrete was set sufficiently hard to permit of its removal, and would then be moved to the head of the line in order to continue the work. The designing of the forms and plant was placed in care of Mr. A. T. Gibson, the chief assistant engineer for the contractors.

While the resultant pressure behind the forms would not be great, their large size, the flotation to be overcome, and the force of the wash from passing steamers was sufficient to make the problem of their design and retention in place a difficult one. A special lifting scow for erecting and removing the forms was also required.

In designing the mixing and laying plant, which was to be on scows, some important points had to be considered.

1. The scows must be narrow and lay parallel (longitudinally) to the banks in order not to obstruct navigation.

2. The ram carrying the box with movable bottom to deposit the concrete required to be operated on a slope of 45 degrees.

3. Its tendency to move with the wave undulations had to be overcome.

4. The ram had also to be so designed that it could be moved past any obstruction on the banks, electric current poles, telegraph poles, etc.

5. The operating machinery of the ram required to be under perfect control and but little agitation of the water behind the forms created by its action.

In addition to these conditions, a supply bin, an automatic hoist and measure, to feed the mixer, had to be designed to suit the requirements of the work. A diving outfit and lifting scow, anchors for the moulds, etc., were also required. It will be thus seen that the conditions were many and somewhat difficult to overcome.

Moulds.—The moulds were constructed of heavy timber, each mould being 100x22 feet, additional width being added at the top by placing longitudinal planks on the part out of the water.

Plate A gives a good idea of the method of construction and the details of the longitudinal trusses to give stiffness to the framework. The heavy timbers were British Columbia fir. A platform or cradle was provided about five feet from the bottom of the mould to hold iron rails for ballast. The entire plan was carefully carried out, and, as will be seen later, the moulds were perfectly successful and rigid enough to be kept in nearly perfect alignment.

Mixing and Depositing Plant.—Plate B gives the general arrangement and details of the mixing plant. The plant is shown in place and ready for operation. It will be noticed that the scow is a narrow one, and that the overhang platform carrying the mixer and receiver hopper is partly counterbalanced by the stone and sand bin. The bin had both a sand and stone compartment, the material being taken from the barges alongside by a clam operated by a stiff leg derrick placed at the other end of the scow.

Measuring Car.—The measuring car, about 32 cubic feet capacity, is shown in three positions, and its method of operation is well worth a careful examination. After being fed by the chute while in its lowest position, the cement being placed in from the side by hand, the car ascends the double-rail track and turns completely upside down (see position 2 and 3). The intermediate position between 2 and 3 would show the rear wheels, first in the air, free of any rail, and next engaging the rail, which carries it while dumping. This apparatus, as designed by Mr. A. T. Gibson, was one of the most efficient parts of the plant.

The feed car dumped into the mixer hopper, and, after the materials were mixed, the concrete was dumped into a receiving hopper, from which the box on the ram was supplied. This supply hopper held about three batches of concrete, and allowed the mixer to be run almost continuously without depending on the speed of the ram, which was at times likely to be irregular.

(To be continued in July.)

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Subaquous Concrete Work

The paper on this subject published this month, though specifically describing work on a canal, is none the less of interest to railroad men in that it is frequently necessary to do concrete work in the presence of water. For example, signal and bridge foundations, retaining walls, etc., must frequently be built in very wet soil or even where the ground is under water, and where the exclusion of the water would be a very serious matter on account of the expense. The paper seems to demonstrate clearly that such exclusion of water is not necessary if there is no swift current or other violent disturbance to interfere with the setting of the concrete.

The Signal Department

The Delaware, Lackawanna & Western has for several years enjoyed an enviable reputation for thoroughness in all things. This characteristic is plainly evident in the signal standards, a description of which is published in another column.

The present methods were originated by Mr. A. H. Rudd, at present signal engineer of the Pennsylvania, and his policies have been ably carried out and amplified by his successor, Mr. M. E. Smith. The chief end desired by the signal department of this road was uniformity without the sacrifice of safety or efficiency. Working with this in view, it has been brought about that a maintainer can be taken from any part of the road and put to work on any other part without the necessity of losing any time studying local conditions. The result has been wonderful flexibility of organization. Another feature of the Lackawanna service is the matter of examinations for promotion. A set of questions was prepared, covering every duty of repairman and batteryman, and the men were required to stand examination on these questions. The fact that the questions were always known to the men beforehand did not lessen the value of the examination, as in learning the answers a man had learned a code of procedure entirely covering his duties.

The road is nearly fully equipped with automatic block signals, and all the more important switches and crossings are interlocked. One of the disadvantages of constant striving for uniformity is seen in the fact that all new installations are still of lower quadrant type, and that one particular type of automatic motor signal has been used for years in spite of improvements in apparatus.

The Railway Signal Association

As announced elsewhere the Railway Signal Association will hold the stated meeting in New York on the 14th of this month. The program of subjects for consideration promises a more than usually interesting meeting. The paper on speed control signals, by Mr. Waldron, should bring out some valuable information. The same may be said of the paper on power transmission and generation, published elsewhere in this issue, which was rather crowded out at Chicago. The meeting will be reported in full in our next issue.

Block System in the U. S.

The Interstate Commerce Commission has just issued the annual report of the Block Signal and Train Control Board, giving length of lines and parts of lines of each railroad in the United States worked under the block system as of January 1, 1910. According to this report there were 65,758 miles of passenger lines so operated. Of this 14,237.7 miles was automatic and 51,520.3 manual. This is an increase of 2,047.1 miles of automatic block signals and 4,162.2 of manual block signals since January 1, 1909, making a total increase of 6,209.3 miles for the year. The report shows that the following roads which heretofore have reported no block signals now use the block system: Chicago, Indianapolis & Louisville; Cincinnati, Indianapolis & Western; Cincinnati Northern; Elgin, Joliet & Eastern; Kanawha & Michigan; Lehigh & New England; Mississippi Central; Spokane, Portland & Seattle; Virginia & Kentucky, and Western Railway of Alabama. These roads represent a total of 2,407 miles of passenger lines operated, 1,097.9 mileso f which are worked by the block system.

The report also contains information showing kinds of signals used and methods of operation. There were 328.3 miles of road protected by exposed disk signals, 1,894.8 miles inclosed disk, 419.1 miles electro-pneumatic semaphore, 10,664.4 miles electric motor, 875.6 miles electro-gas. Of these 18,343.1 miles were normal clear and 5,428.5 normal danger. There were 24,380 block sections.

Of manual block there were 39,477.4 miles operated by telegraph, 8,105.0 miles by telephone, 945.1 by electric bells; 1,909.5 miles had no track circuits, 385.8 miles had track circuits at stations, and 491.5 miles had continuous track circuits. There were 270.2 miles of train staff. Of a total of 9,898 block stations 3,713 were closed part of the time.

Under the manual block system 7,832.8 miles were under absolute block, 11,840.4 miles under permissive block by three position signal, 10,725.5 miles by two position signal and flag or lantern, 22,816.9 miles by caution card. On 9,934.1 miles rear end protection only was afforded. A stop at the station was recognized as a stop for the signal opposite on 24,776.4 miles.

There is a supplementary table showing that telephones are used for train dispatching on 26,344 miles of road.

This report shows that a very encouraging disposition existed among general managers to extend the use of the space interval even during a time of money stringency. This is perhaps one of the most hopeful signs of the times. The block system has repeatedly proved its value, not only as a safety device, but also as a money-earner, by increasing the capacity of a road, postponing the necessity for additional tracks, and making possible a reduction in operating expenses, since fewer telegraph offices are needed.

Railway Signal Standards.
No. 7. Delaware Lackawanna & Western

The Lackawanna is a lower quadrant, two position road. On double track most signals have two arms and are exactly similar to that shown in Fig. 59. On single track, single arm signals are used. Electro-motor and electro-pneumatic signals are both in service, but by far the greater number are electro-motor. Fig. 139 shows the home blade and Fig. 140 the distant. It should be noted that both are yellow. Interlocking home signal blades are red. The spectacle is shown in Fig. 149. The stroke of the arm is 60 degrees.

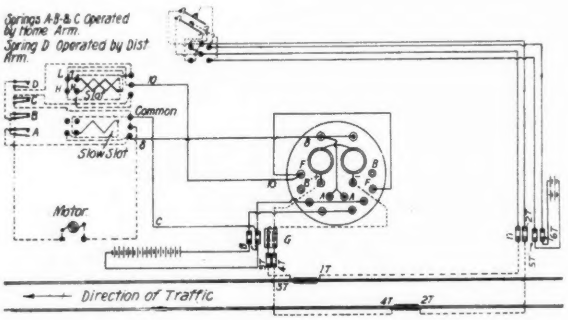


Fig. 141.—Wiring, Diagram for Automatic Block Signal Controlled by Polarized Track Circuit, Lackawanna.

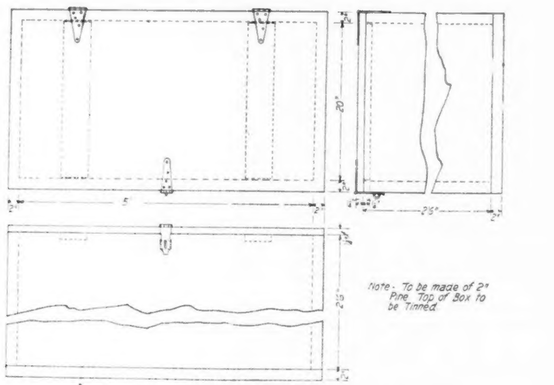


Fig. 143.—Wooden Battery Box, Lackawanna.

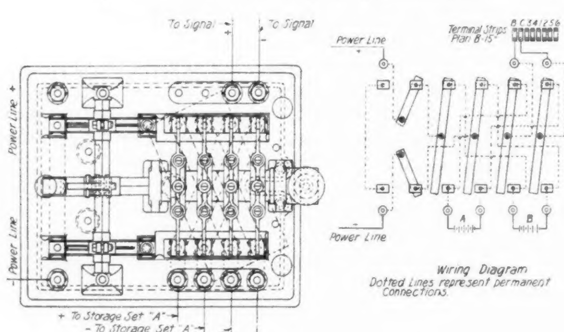


Fig. 148.—Storage Battery Charging Switch for Signal, Lackawanna.

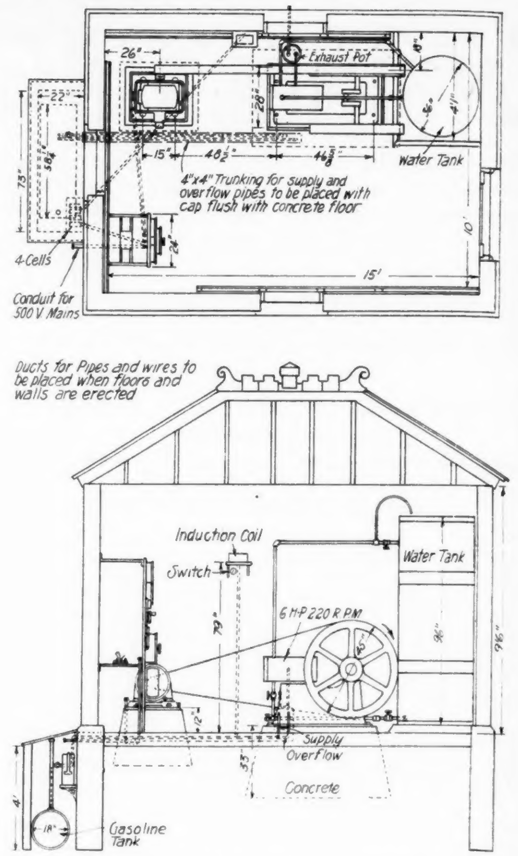


Fig. 146.—Charging Station, Lackawanna.

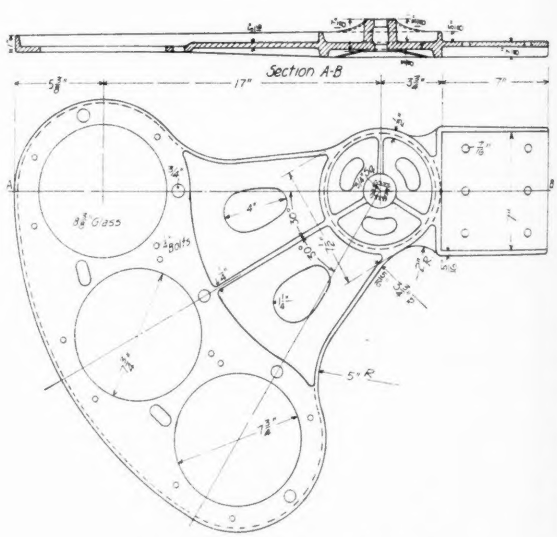


Fig. 149.—Spectacle, Lackawanna.

All automatic block signals are normal clear and on double track are controlled wherever possible by the polarized track circuit, no line wire being required, see Figs. 141, 142. Wherever line wires are needed, owing to crossing bells, interlocking plants, or on single track, a separate line is not used. The wires are strung below the telegraph line on the same poles. The installation conforms to Western Union standard.

The night color indications of all signals are: red, stop; yellow, caution; green, clear. All signals have the mechanism located at the base of the post. They are operated by either potash or storage battery, housed in a case at the base of post, wooden box, or well as conditions require. Figs. 143, 144 show wooden battery boxes, and Fig. 145, an iron well. Concrete wells are also used. The same battery operates the signal and controls line circuits when required. When storage batteries are used they are charged from a line. Fig. 146 shows a charging station with the necessary machinery, Fig. 147 a distributing switchboard for above, and Fig. 148, a charging switch.

Signals and cut sections are installed as shown in Figs. 150, 151 respectively. Bootlegs are made of wooden trunking and

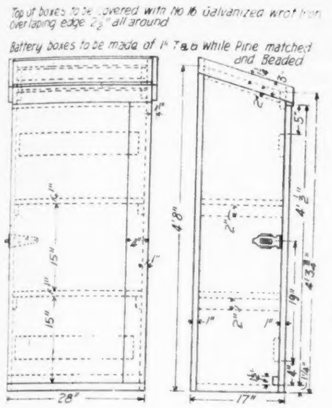


Fig. 144.—Wooden Battery Box, Lackawanna.

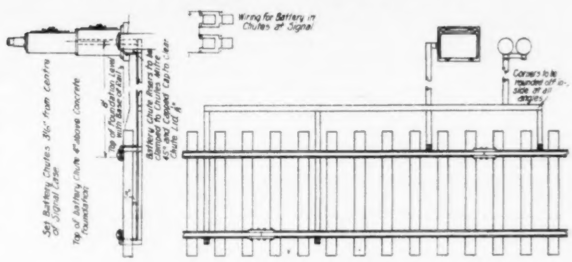


Fig. 150.—Layout of Apparatus at Automatic Block Signal, Lackawanna.

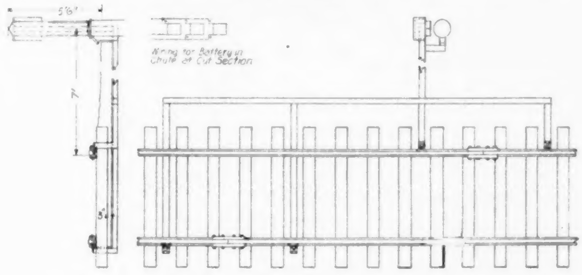


Fig. 151.—Layout of Apparatus at Cut Section, Lackawanna.

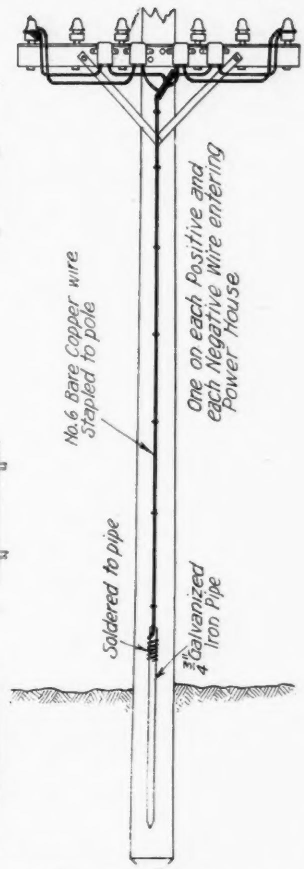


Fig. 177.—Lightning Protection for Charging Line, Lackawanna.

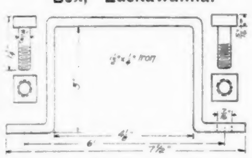


Fig. 155.—Trunking Clamp for Battery Chute, Lackawanna.

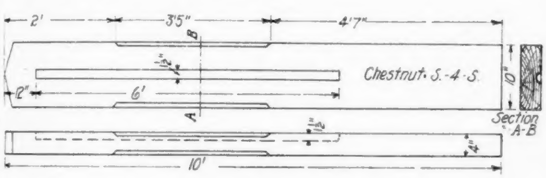


Fig. 164.—Relay Post, Lackawanna.

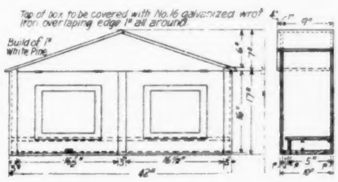


Fig. 163.—Relay Box for Signal Bridge, Lackawanna.

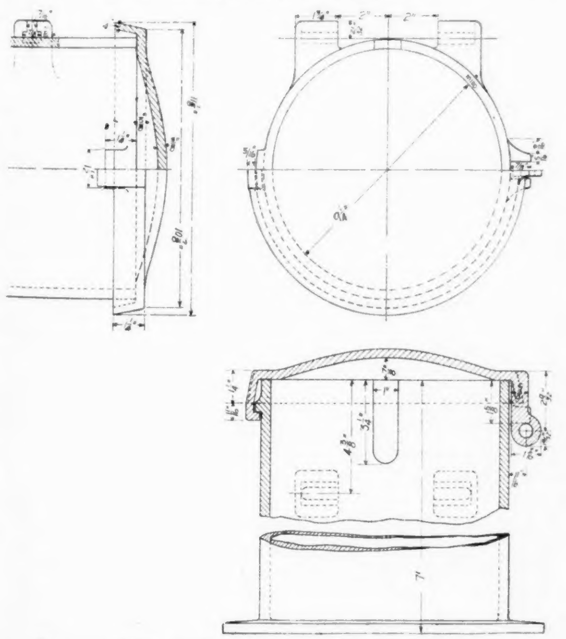


Fig. 154.—Cast Iron Battery Chute, Lackawanna.

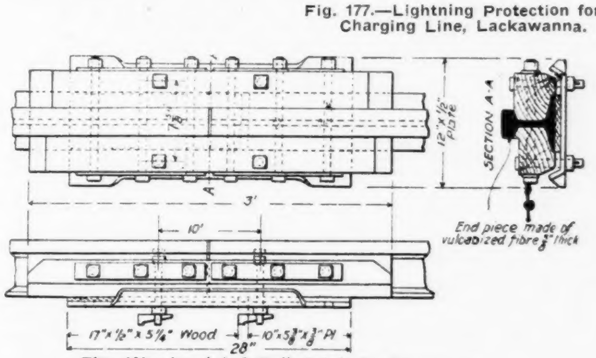


Fig. 169.—Insulated Rail Joint, Lackawanna.

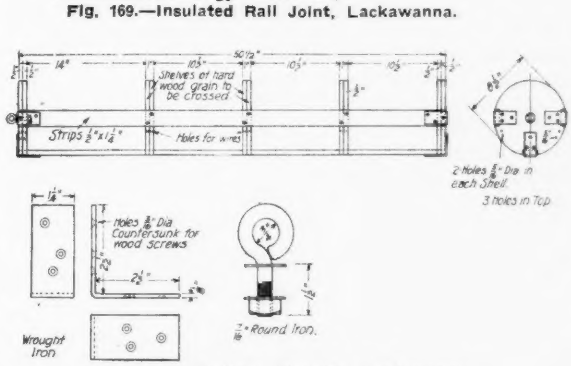


Fig. 156.— Battery Elevator, Lackawanna.

capping, Fig. 152 which is used exclusively for wire ducts and installed below ground.

Fig. 153 shows a signal foundation and a platform for the convenience of the maintainer, when the foundation is installed on a fill.

Track circuits are fed usually from four cells in series parallel of gravity battery housed in iron chutes, Fig. 154. The clamp for holding trunking in place against the side of the chute is shown in Fig. 155. The elevator appears in Fig. 156. Track circuits are of an average length of 4800 ft. which is also the usual length of a block. Cut sections are used as little as possible. Methods of taking track circuits through various arrangements of switches are shown in Figs. 157, 158, 159 and 160. Fig.

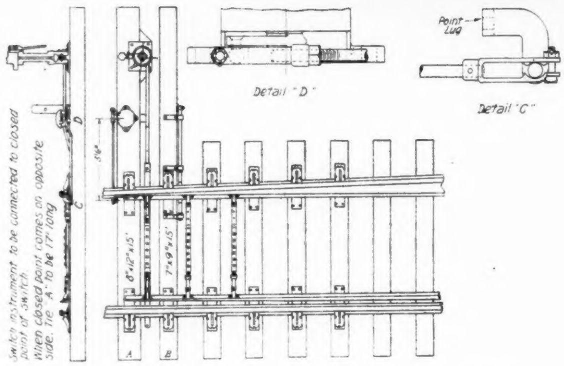


Fig. 161.—Method of Connecting Switch Box to Points. Lackawanna.

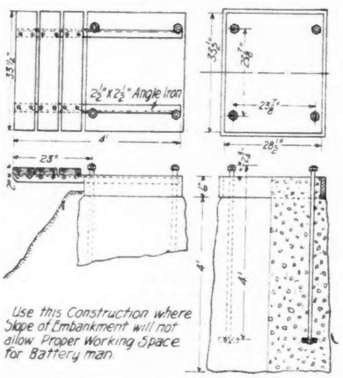


Fig. 153.—Signal Foundation, Lackawanna.

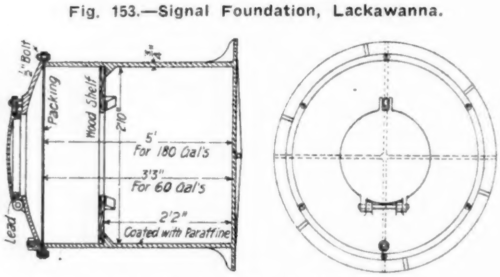


Fig. 178.—Oil Tank, Lackawanna.

161 shows how a switch instrument is connected to a point. Switch indicators are not used.

Relay boxes, Figs. 162, 163, are of wood as are the supporting posts, Fig. 164.

Fig. 165 is a typical layout of automatic block signals on double track, while in Figs. 166, 167 and 168, which are continuous with one another, is shown the standard arrangement of signals on single track together with a diagram of overlaps. The standard insulated rail joint appears in Fig. 169.

At interlocking plants in block signal territory, the home

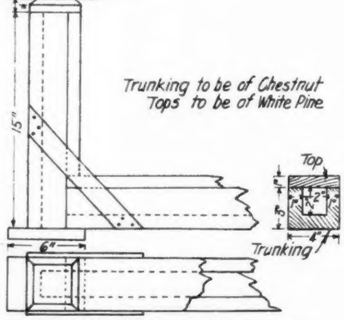


Fig. 152.—Bootleg, Lackawanna.

signals are slotted and the distant signals power operated. Typical circuits for double track are shown in Fig. 170; this includes indicators, annunciators and electric locking. Figs. 171 and 172 show the same for single track together with crossing bell and automatic block signal circuits. In Figs. 173, 174, 175 and 176 appear route locking circuits used in connection with electro-pneumatic interlocking.

Fig. 177 shows how charging wires are protected from lightning.

Fig. 178 illustrates an oil storage tank, used to supply lamps.

All relays meet the R. S. A. specifications. Track relays have a resistance of 3½ or 4 ohms, line relays of 500 ohms.

The following sizes and classes of wire are standard: For line No. 9 and No. 12 B. & S. gage galvanized iron, weatherproof insulation; for bootlegs and leads from track, No. 6, B. & S. gage rubber covered copper; for leads from line, No. 12 B. & S. gage rubber covered copper; for leads from battery, No. 9 B. & S. gage rubber covered copper; in chutes, No. 12 Stranded rubber covered copper.

(To be continued in July.)

The Chicago, Milwaukee & St. Paul is installing three-position upper-quadrant, automatic semaphore block signals on double track between St. Paul and Minneapolis.

An officer of the Oregon Short Line writes that 300 miles of new automatic block signals, the construction of which has heretofore been announced, are now being put up. They are on the Utah and Idaho divisions of the road. When this work is finished the Idaho division will be completely signaled from Granger, Wyo., to Huntington, Ore., a distance of 540 miles. The signaling of the Utah division will be completed from Sandy, Utah, to Cache Junction, 100 miles. It has been reported that an appropriation has been made for installing signals on the Southern Pacific line across Great Salt Lake. As a matter of fact there is no new construction to be done on this line, as it is already fully signaled; but the officers of the road are considering using the staff system on that portion of the line where the salt water of the lake interferes with the working of the track circuits.

The Duluth & Iron Range Railroad is installing automatic block signals between mile posts 27 and 51 on double track. These signals will be installed by the General Railway Signal Co., and will give three indications in the upper right-hand quadrant. They are of the "Model 2A" top post type and will be operated by portable storage batteries housed in concrete wells. There will be nine signals in this installation.

The interlocking plants at Chaney Jct., and Sherman, Tex., on the Houston & Texas Central R. R., are being revised. Treated wood trunking is being used.

The Santa Fe signal department has just received authority for the construction of 125 miles of A. C. three position upper quadrant signals on the Coast Lines. These signals are to be installed as fast as the double tracking is completed.

The Central Railroad of New Jersey is installing a 48-lever interlocking plant at Bethlehem Jct., Pa. A Saxby & Farmer machine will be used. Signals are to be semi-automatic, and approach and indication locking will be used.

The Waterloo, Cedar Falls & Northern, an electric railway at Waterloo, Ia., will shortly install an interlocking plant at the crossing of the Rock Island. The contract for this plant has been awarded to the Federal Signal Company. A mechanical machine controlling power operated upper quadrant signals on the Rock Island and mechanical dwarf signals and derails on the electric road will be installed. The apparatus will be so arranged that the route for Rock Island trains will be normally lined up; and the plant will be operated by the crews of the electric cars.

The Maintenance of Way Department

Distributing Ties and Rail for New Work

Editor, Railway Engineering.

When unloading rail for building second track, which is parallel with the old main line, I use a skid which is made of a push car, with a 12-in. x 12 in. x 8 ft. timber placed across the front end. On this is placed a piece of track rail and a V-shaped rail is placed on the center of the 12x12. The ends of this V-shaped rail run back to the rear corners of the push car, with enough incline to cause a rail to slide off and drop along side of the track. This car is coupled to the rear of the car to be unloaded. Two ropes 35 ft. long with a hook in one end and a clamp 24 ins. long on the other are provided. The clamp is placed over a rail with the end projecting out over the end of the ties and the hook is then placed in the hole in the end of the rail in the car, and the train started. This drags the rail out of the car. This arrangement can be used very satisfactorily unloading rail out of stock cars, coal cars, if end can be taken out, or flat cars.

Unloading rail in this manner if rails are piled straight in cars, only requires a gang of about eight men. When rails are loaded in steel coal cars, where the rails have to be taken out over the sides, I use the American rail loader to lift them out of the car and place them on the ground. When a machine like the rail loader is not available, I use skids which are placed on the sides of the car and blocks and falls to lower the rails to prevent their dropping and bending. On parallel tracks, where the old grade is higher than the new, and where new grade is close enough to do so, I use the American rail loader to set the rails over on the new grade.

We load ties on flat cars and distribute them on new grade with work train, dropping them along the side of the track. If the new track should be higher than the old track, we use planks for runways from the car to the new grade and have men carry them from the car to the new grade.

Missouri. Roadmaster.

Editor, Railway Engineering.

For rail renewals or double track, I unload 85-lb. rails with 10 or 12 men, using two pieces of 1½-in. rope about 45 ft. long, and what we term an "A" or drag. This is a piece of old iron rail about 22 ft. long, bent in the middle to form the letter "A", cutting the base out of it so it will bend readily. The two ends of the rail are also bent down; this forms a sled runner. I generally bend about one foot on the end of each rail. The ends of this drag hang on the outside of the track rail and the apex is hung over a pin in the drawbar of the car to be unloaded. I put a loop hole in one end of each of the ropes. One man with a bar at these loops or outer ends, places the bar through the loops and behind the end of a tie. On the other end of the rope I apply hooks just long enough to place through the bolt hole in the end of the rail. A man outside the car handles the hooks and a middle man on the rope helps carry it forward. Four to six men work in the car to separate the rails. We apply the rope, move the engine and car forward and pull the rail out. The man that handles the hook stays in the middle of the track and by laying his hand on one end of the rail as it passes out of the car, places the rail to the outside of the end of the ties. After the rails are far enough advanced, they will pull out of themselves. We then stop, move the rope forward for another hitch for two more rails. When the end of the rail that is in the car drops off the end of the sill, it has a fall of 15 or 20 inches before it strikes the drag which is hung on the drawbar and slides down on the end of the tie and rolls off. After the men become used to the work and get posted as to the length of their ropes, the rail can be distributed as easily and quickly as any method I know of and cheaper than any other that I have tried. This method is used where we relay rails or for double tracking, and the number of cars unloaded depends on how many trains you have to let by. I have unloaded 16 cars of 75-lb. rails with 14 men in a day and never experienced any trouble, such as bending, kinking or destroying rails, and have gotten the full use of the work train.

In unloading ties I always, before starting to unload, put four men in a car and have the men place the ties at the car door. For instance, if I am working 10 cars and I want to unload 50 ties at a place, the men in each of the cars will place five ties at the car door to be thrown out on signal. I personally stay outside on top of the train and give the engineman a signal for two blasts of the whistle. When this signal is given, the men in each car throw out the five ties. They can be gotten as thick as you want them in this way. There is no delay and you can maintain speed enough with the train to make the ties go in the clear when you give the men the signal to toss them out. On a high fill, the speed has to be held down so that you will not get the ties down the dump, and in cuts you have to be careful that the ties do not roll back under the train. Where fill is already made for double track, you can unload ties rapidly this way, as it has a tendency to make the men hurry up and get the ties in the door to be ready to toss them out when they receive the signal. I have unloaded 36 cars of ties with 22 men and 4 foremen in a day. The amount of work done this way depends on the number of trains you have to contend with, and the number of ties in the car. Creosoted ties, if they are fresh from the treating plant, are very heavy, but after the men get them started to sliding, they handle quite readily.

Kansas. Roadmaster.

Editor, Railway Engineering.

Without the convenience of a track-laying machine we use teams to distribute six ties per rail on the dump ahead and transfer our rails onto a rail truck car and move them ahead by hand. This, of course, is not an up-to-date method of track-laying, as I believe all construction companies use track-laying machines which expedites and simplifies the matter, laying its ties and rails as it goes along. Superintendent.

Colorado.

Editor, Railway Engineering.

The rails, ties and fittings are first distributed rather roughly along the second track from existing main line. The rails are dragged off the cars by hitching a chain to them, fastening one end to present rails and moving work train ahead.

The method used in laying track is about as follows. A party goes ahead, clearing the new roadway of kegs of spikes, rail fastenings, etc., another party lays the ties, spacing roughly with the eye. Then a third party accurately spaces the ties and lines up one end of them; a fourth party marks the position of one rail on the end of the ties which have been lined. They are followed by men who lay a tie plate and drive a spike part of the way into the tie on the end lined. The main gang places the rails on the ties, first spiking the rail on the side which has been accurately lined and gauging the other rail to it. After men are trained to this everything moves along smoothly and good business is done. Division Engineer.

California.

Editor, Railway Engineering.

On construction of new tracks, such as third and fourth tracks, passing sidings, etc., parallel to our present lines, distribution of ties, rail and other material is handled by work train on the present tracks. Division Engineer.

Pennsylvania.

RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

Railway Signal Association

Program, Stated Meeting, New York, June 14, 1910.

Meeting will be held at the Engineering Societies Building, 29 West Thirty-ninth street.

Morning Session—10:00 a. m. to 12:30 p. m.

Subjects—Regular order of business, including Committee Reports.

Sub-committee on Standards will present for consideration the following standard designs:

Semaphore Lamp.

Lamp Equipment (Font and Burner).

Short Pinnacle and revised tracing of the Long Pinnacle.

Standard Binding Post.

Concrete Pipe Carrier Foundation.

Ladder Foundation.

New tracing for base of Bracket Post.

Committee No. 4 will present for consideration:

Proposed Specifications for D. C. Relays.

Proposed Specifications for Hard Fibre.

Proposed Specifications for Tinned Channel Pins.

Proposed Specifications for Trunking and Cover.

Proposed Specifications for Caustic Soda Primary Battery.

Afternoon Session—2:00 p. m. to 5:30 p. m.

Subjects—Description of the World Signal, illustrated by lantern slides, J. H. Wisner, Jr.

Speed Controlled Signals, J. M. Waldron.

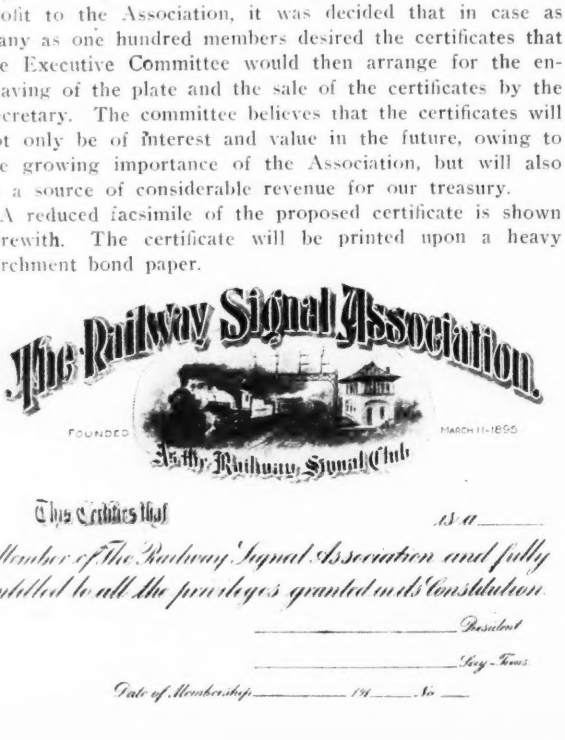
The paper on "The Generation, Control and Transmission of Alternating Current for Railway Signaling," presented at the March meeting by Messrs. Rhea and Kimball, published in another column, will be given further consideration.

Proposed Membership Certificate.

At the last meeting of the Association, sample certificates of membership were exhibited which would cost members desiring them $1.25 each.

As the sale of one hundred of these will be sufficient to pay for the plate, and then any future sales would bring a profit to the Association, it was decided that in case as many as one hundred members desired the certificates that the Executive Committee would then arrange for the engraving of the plate and the sale of the certificates by the Secretary. The committee believes that the certificates will not only be of interest and value in the future, owing to the growing importance of the Association, but will also be a source of considerable revenue for our treasury.

A reduced facsimile of the proposed certificate is shown herewith. The certificate will be printed upon a heavy parchment bond paper.


The Railway Signal Association.
FOUNDED MARCH 11-1895
As the Railway Signal Club
This Certifies that ______ is a
Member of The Railway Signal Association and fully entitled to all the privileges granted in its Constitution.
______ President
______ Secy-Treas.
Date of Membership ______ 191__ No. ___

Fire Control on the Great Northern and Northern Pacific

Secretary Wilson, of the Department of Agriculture, has made an agreement with the Great Northern and with the Northern Pacific for co-operation of the Government Forest Service and the railways to prevent damage to the national forests from fires. The companies agree to clear and keep clear of inflammable material a strip of varying width, as conditions may demand, up to 200 ft. outside of the right of way, and to provide all locomotives which do not burn oil with suitable spark arresters and other standard equipment to prevent the dropping of fire. It is also stipulated that every effort will be made by the companies to operate their locomotives so as not to cause fires. Prompt notification to forest officers of all fires discovered by employees of the railways is provided for, and telephone lines to make this possible will be put up by the Forest Service. Except for salaries of regular employees the cost of fighting fires which start within 200 ft. of the railways will be borne by the companies and of all others by the Forest Service, unless it shall be shown in the first case that the railways were not responsible, or in the second case that they were responsible for the outbreak of the fire.

The Forest Service will regularly patrol the rights of way during the fire season. The Northern Pacific, being a land-grant company, owns a great amount of timber on the alternate sections along its line. The Great Northern, although it is not a land-grant road, also has property at stake in its buildings and the line itself, operation of which may be seriously interfered with by forest conflagrations. The value of heavy timber in mountainous regions as a deterrent to avalanches, landslides and floods is also to be considered as well as the general industrial prosperity of the country.

Railway Contractor Now an Employee

An important ruling has been made by Assistant Attorney General Crawford, of the state of Texas, who advised the railroad commission that a railroad company can not transport free the employees of a grading contractor, nor can it deadhead the outfit of the contractor, consisting of his tools, implements, etc., to a point on the line where grading is to be done. It was in the case of the Missouri, Kansas & Texas Ry., and it asked if the employees of the grading contractor could be carried free and if the road could transport the outfit free. Mr. Crawford finds that the employees of a grading contractor are not the employees of a railroad company as defined in the exemptions in the anti-pass law, therefore are not entitled to receive and use free transportation. And the same applies to the outfit; it is not included in the exemptions in the law. Judge Crawford declines to pass on the question of whether or not the contract could have legally called for such transportation as part of the consideration in the controct. Inasmuch as the question was not presented because there was no such provision in the contract, he does not go out of his way to pass upon it.

New Signals on the New York Central

Between the third and the twelfth of March, 1910, thirty-one three-position, upper right-hand quadrant, signals were placed in service between Mount Vernon, N. Y., and North White Plains, N. Y., on the Harlem division of the New York Central & Hudson River, eleven miles of double track throughout. The signals are "Model 2A," made by the General Railway Signal Co., and are operated from a 25-cycle, 2200-volt alternating current line. Electric lights are used for the night indications. The track circuits are alternating current, center fed; and the signal motors operate on 169 volts.

On March 16, 1910, electric traction was substituted for steam.

Trains are operated by direct current at 660 volts, with third rail distribution.

About May 15 an 88-level all-electric interlocking machine, style 2 of the General Railway Signal Company's manufacture, was placed in service at the south end of the North White Plains yard. All high signals at this point are "Model 2A," three position, giving indications in the upper right-hand quadrant. The signal motors will use alternating current at 169 volts. The dwarf signals which are of the motor dwarf type manufactured by the General Railway Signal Company, will be operated by direct current at 110 volts. Alternating current track circuits of the one-rail type will be used, and detector track circuits will also be installed. The switch and lock movements are to be No. 4 type. The electric lock levers are alternating current, normally de-energized, and picked up through the medium of the lever latch.

With the Manufacturers

Culvert Pipe

The two types of cast iron culvert pipe illustrated herewith are made by the Galion Iron Works Co., of Galion, O. The following comments and description are taken from their circular:

The life or lasting qualities of a culvert is the all important question. Its life depends upon: First, the kind and quality of material used; second, strength as embodied in design and construction; third, the finish given. The higher the attainment in these qualities the nearer we approach "perfection" in culverts.

It is a well-defined mechanical principle that to obtain maximum strength in cast iron "make it with ribs." The system of ribs is on the top crown of the pipe, where the pipe should be strong. The ribs make Perfection and Ideal cast iron pipe absolutely the strongest culvert pipe ever produced. The ribs also make it impossible for the pipe to shift or get out of place, and should a wheel cut through it strikes a rib, the strong point. The great foe of wrought iron or steel is rust, but it is a fact that a good quality of cast iron properly coated or finished is practically rust proof. Cast iron water pipe has been taken up in perfect condition after being in constant use 100 and 200 years. Perfection and Ideal cast iron pipe will last as long. Simplicity is the soul of mechanics. Perfection and Ideal culvert pipe is made in lengths or joints four feet long, each joint being constructed of two half-round longitudinal sections, each section having lugs on each side by which they are bolted together complete in form of round pipe.

If there is any danger of culvert freezing full of ice it is simply necessary when installing the culvert to loosen the four lug bolts which allow for expansion. The ice will then lift the top half, and when it melts gravity will force it back to its normal position. Thus we have the most practical expansion feature known. These two cast iron culvert pipes embody every known desirable and practical quality to make them the real Perfection or Ideal culvert.

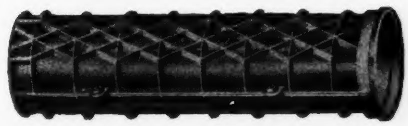
After the cast iron pipe is cleaned and finished complete it is put through a hot bath of black asphaltum pitch. Being applied hot, it gives the pipe a permanent coat of black that will never come off and insures it against any possibility of rust.

Wood plank culverts rot out quickly and are a thing of the past. Clay sewer pipe cracks with frost and is easily broken. Concrete culverts require an extra high roadbed to put them in at all, and only about one concrete culvert in six stays in, because the foundation is not solid and not put down below the frost line. If the concrete culvert settles a particle the entire work and material is lost.

Another of their products also illustrated herewith is the Sterling corrugated culvert pipe, of which they say as follows:

The material used in the manufacture of Sterling corrugated metal culvert pipe is a very high grade of sheet metal of a special analysis and is double galvanized. Sterling metal sheets are guaranteed the best and purest sheets ever used in corrugated culvert pipe. This pipe is manufactured

Corrugated Iron Culvert.



Cast Iron Culvert.

by special machinery. The corrugations make it many times stronger than plain pipe. It is made up of two-foot sections, each section having an angle flange one inch high, turned up at each end. The sections are then tightly attached by joining the two flanges of the adjoining sections securely together from end to end and in the most substantial manner. The double angle flanges every two feet make the Sterling 25 per cent stronger than any other corrugated pipe. Sizes are taken between the inside corrugations. This makes the Sterling pipe from 10 to 25 per cent greater in capacity.

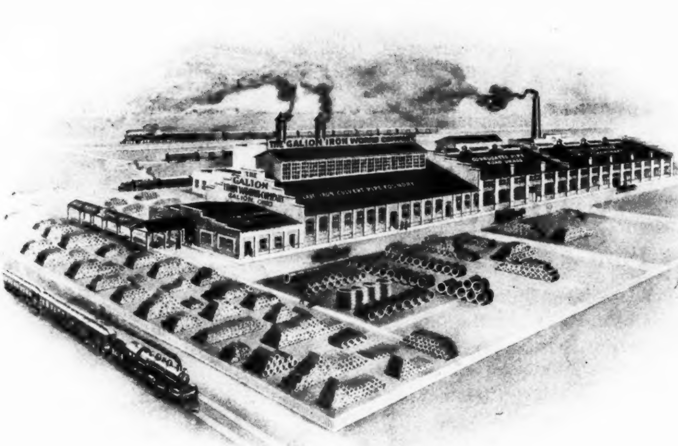
Sterling corrugated pipe is built complete before shipment and is not open to the objectionable features of sectional pipe, which has to be built on the work out of a mixed lot of parts which are always bent—out of shape—or broken —parts short—bolts missing, etc. Sterling pipe comes complete ready to roll in position without the annoyance and heavy expense in hunting up tools and parts and hiring an expert to assemble.

This company also makes Perfection cast iron bulkheads or headers for culvert pipe, nickel steel road machine blades, road drags or levelers, reversible road machines, Reliance rock crushers, Eureka road rollers, scrapers, catch basin covers, plows, gasolene engines and fireproof safes.

An Economical Method of Supplying Water

There are hundreds of places where it is desired to elevate water to supply residences, railroad tanks and irrigation plants, yet the cost of fuel and attendance is prohibitory. In all such cases, provided there is a fall of at least two feet to furnish power to operate it, a hydraulic ram will solve the problem very satisfactorily. It is entirely automatic in operation, and will pump day and night for months without the slightest attention, and when once installed there is no further expense. The construction of one of these rams is simplicity itself, a feature that greatly favors the selection of this device where it is to be used at a distance from repair shops.

The accompanying illustration shows a plant recently installed by the Rife Pumping Engine Company, Room 2118, 111 Broadway, New York, for the Colombian Government at Agua de Dios. The installation consists of three rams having a total capacity of from 210 to 230 litres per minute, which raise this quantity of water to a height of 65 metres through a line of 6-inch iron pipe, approximately 4,200 metres long. The work was unusually difficult and a number of

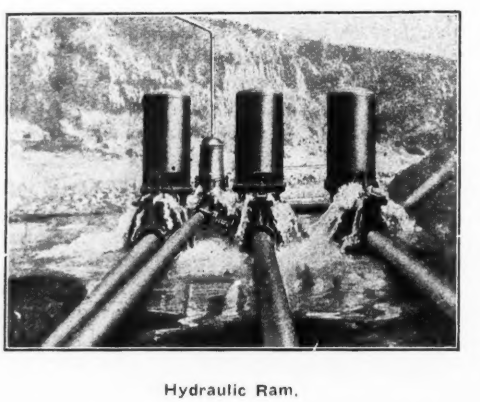


Plant of Galion Iron Works Co.

obstacles had to be overcome before the town could have a supply of fresh water. Now that the system has been completed, it is the intention of the authorities having the matter in charge to distribute the water to the dwellings of the town as well as to several fountains and a public bath. When this work is entirely finished, this South American town will have a system of water supply not to be excelled by any town similarly located.

The hydraulic rams of this concern are used in the testing laboratories of nearly all the prominent American colleges and institutions of learning; on 35 different railroads to supply a large number of railroad water tanks; in connection with several projects of the United States Government Reclamation Service, and to supply water to over 7,000 private residences and stock farms all over the world.

The manufacturers claim that these rams will work successfully under a fall of water of two or more feet and will elevate the water 30 feet for each foot of fall. The double acting rams may be operated with impure or muddy water as



Hydraulic Ram.

power and deliver spring or potable water without the two kinds becoming mixed in any way. They can also be used to fill roof or tower tanks, and where these types are objectionable the rams will discharge into a pneumatic tank under pressure and supply sufficient air for both the ram and the tank.

This firm has been making a large number of installations in Mexico, Central and South America and other foreign markets.

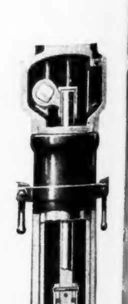
Duff-Bethlehem Jacks

Fairbanks, Morse & Co., have just put on the market a new hydraulic jack, entirely of forged steel, made by the Duff Manufacturing Company. The hydraulic jack had received in years past quite a bad reputation on account of leakage of pressure, so that it would not hold the load, due to the number of joints and packings. Heretofore jacks have been made of castings, which permitted leakage and were not sufficiently strong to stand great pressure without having the castings so heavy that the jacks were unwieldy and inconvenient to carry.

In the Duff-Bethlehem hydraulic jack each part is a steel forging, so that practically every joint is eliminated and the entire jack contains but two small packings. This construction makes the ram of the Duff-Bethlehem jack a one-piece forging together with the pump chamber eliminating all packings and joints in the ram. The cylinder and base is also a one-piece forging so that there is no packing and joint at the bottom of the cylinder. This construction prevents leakage, and permits much greater pressure, resulting in an "hydraulic jack" that weighs from 30 per cent to 80 per cent less than any other make of equal size and capacity, permitting it to be conveniently carried and put under all classes of work. The valves are so improved and located that the jack can operate at any angle, with its full range of lift. The reservoir is self-contained and the cylinders are of sufficient excess strength fully to withstand any unequal pressures due to poor foundations. The valves are positive and can be attended to without removing the packing and the packing without removing the valves. Both the cylinder

Telescopic Hydraulic Jack.

Duff Ball Bearing Jack.



Forged Steel Hydraulic Jack.

and the ram have a solid bottom. The axis of the pump stroke coincides with that of the pump well, which insures uniform wearing of the pump packing.

These jacks are made in all types, all capacities, and many sizes are specially designed for railroad work and for the handling of locomotives, pullman, passenger and freight cars. The Duff-Bethlehem jack is also made in a journal box type for removing brasses in journals. The "independent pump" type of hydraulic jack is another of the forged steel developments in this line which contemplates lifting capacities from 100 tons to 500 tons inclusive. In this type the jack and pump are separated and connected by flexible copper tubing. This type is useful where it is inconvenient to operate the ordinary type of jack owing to the lack of room for the operation of the lever or insufficient space for the placing of the jack.

Another class of jack made by the same company is the Duff Ball Bearing Screw Jack, which is made in all types and sizes. It contains an improved ball bearing in that the balls are much larger in size than is usual, therefore much stronger and capable of greater strains as well as operating much more easily under a load. Special tool steel plates are provided to take care of these balls in the main bearing so that practically no wear occurs during the constant operation of the jack in the most severe service.

Another improvement is an additional bearing on the bevel pinion to take the thrust at that point. The Duff jack is the only one containing a bearing at this point. All other jacks of this character are made with plain surfaces rubbing together. In both bearings in the Duff jacks the balls are separated by a bronze cage, eliminating all friction between the balls. The Duff Manufacturing Company also makes a cone bearing journal jack in capacities of 10 and 15 tons for use by car inspectors.

The regular Duff ball bearing screw jacks range in capacities from 10 tons to 75 tons and are made in various sizes and with and without foot lifts. Special sizes are provided for the handling of railroad equipment for shop work. All gears are high carbon steel, drop forged, and have machine cut teeth.

Personals

W. D. Hodge has been appointed chief engineer of the Denver, Laramie & Northwestern, with office at Denver, Colo., succeeding E. A. Buck.

G. H. Cravens has been appointed chief engineer of the Memphis, Paris & Gulf, with office at Nashville, Ark., succeeding H. C. McCluer.

The office of S. P. Hull, engineer maintenance of signals of the New York Central & Hudson River, has been transferred from New York City to Albany, N. Y.

H. R. Safford, chief engineer maintenance of way of the Illinois Central, at Chicago, has resigned.

"On the Clover Leaf we have just finished grade reduction to 35 ft. to the mile at East St. Louis, going east to the Mississippi valley bottoms. This means an increase in the maximum train haul from 1,200 to 1,600 tons. The Clover Leaf is gravel ballasted except in the eastern division, where the ballast is rock. We have contracted for 50,000 yds. of rock for the eastern division, or about 33 miles of rock ballast.—*G. H. Ross, vice-president.*

Morris K. Trumbull, engineer of track elevation for the city of Chicago, has been appointed principal assistant engineer of the Chicago & Western Indiana and the Belt Railway Company of Chicago, with office at Chicago.

L. G. Curtis, division engineer maintenance of way of the Chicago division of the Baltimore & Ohio, at Chicago, has been appointed engineer maintenance of way of the recently organized Northwest system. E. D. Jackson, assistant engineer at Baltimore, Md., succeeds Mr. Curtis.

A. S. Kent, division engineer of the Chicago, Indianapolis & Louisville at Chicago, has been appointed engineer maintenance of way, with office at Chicago. Anton Anderson has been appointed division engineer of the First and Second divisions, with office at La Fayette, Ind., succeeding W. A. Wallace, resigned.

Mr. George W. Arnold, who has been engineer in charge for the construction of a number of large tunnels within the past few years, has been appointed division engineer for the Western Maryland, with office at Myersdale, Pa.

Mr. M. K. Trumbull has resigned his position as engineer of track elevation, of the city of Chicago, to become principal assistant engineer, with the Chicago & Western Indiana and Belt Ry. Co., of Chicago. Mr. Horace S. Baker, formerly head of the designing bureau of the city engineer's office has been appointed to take up the track elevation work.

Mr. M. V. Hynes, formerly division engineer of the Cincinnati, Hamilton & Dayton, has been appointed acting engineer of maintenance of way with office at Cincinnati, O.

Mr. John Henry Miller, who conceived the plan and constructed the Baltimore & Ohio Belt line tunnel under the city of Baltimore, and who also planned the great Susquehanna electric power plant at Conowingo, died April 24.

Mr. P. Gratton, formerly roadmaster on the Kansas City Southern Mo., has been appointed general roadmaster in charge of the Kansas City terminals and the Northern division with headquarters at Kansas City, Mo.

Mr. J. Gratton, formerly roadmaster on the Kansas City Southern at Neosho, Mo., has been appointed a general roadmaster with jurisdiction over the territory south of Mena, Ark., with office at Texarkana, Tex.

Mr. A. J. Bell has been made inspector of station service on the Baltimore & Ohio with headquarters at Wheeling, W. Va.

J. B. Carothers, superintendent of the Illinois division of the Baltimore & Ohio Southwestern at Washington, Ind., has been appointed chief engineer maintenance of way, succeeding Earl Stimson, promoted.

Le Grand Parish, superintendent motive power of the Lake Shore & Michigan Southern at Cleveland, Ohio, has resigned to become president of the newly formed American Arch Company, New York.

Work has been started at La Union, Salvador, on the eastern division of the Pan-American Railroad, and the occasion was this week celebrated with banquets throughout the eastern part of the republic. The concession was granted to Miner C. Keith and Bradley M. Palmer, of the United Fruit Company.

Mr. George A. Blackmore has been appointed assistant eastern manager for the Union Switch & Signal Company of Swissvale, Pa., with headquarters at New York. Mr. Blackmore will be associated with Sidney G. Johnson, who was recently appointed general sales manager. Mr. W. M. Vandersluis has been appointed assistant eastern manager, with office at Chicago, to succeed Mr. W. E. Foster, resigned.

On May 1, Mr. Harold K. Ferguson, assistant signal engineer for the Santa Fe, was appointed to a position in the signal department of the General Electric Company, where he will be associated with Mr. Frank Rhea.

Mr. Edgar Winans, chief draftsman for the Santa Fe, on May 1 was appointed assistant signal engineer with headquarters at Topeka.

On May 1, Mr. J. E. Saunders was appointed assistant signal engineer for the Santa Fe Railway.

James S. Sheafe has been appointed engineer of tests of the Illinois Central, the Indianapolis Southern and the Yazoo & Mississippi Valley, with headquarters at the Burnside shops, Chicago, reporting to the general superintendent of motive power. The test department will make inspections and tests not only for the mechanical departments and supply departments, but also for other departments of the road needing its services.

J. D. Maupin, general foreman of the Trinity & Brazos Valley at Teague, Tex., has been appointed master mechanic. L. M. Jacobs succeeds Mr. Maupin.

Lawrence A. Downs, assistant engineer maintenance of way of the Illinois Central, the Yazoo & Mississippi Valley and the Indianapolis Southern, was born in Greencastle, Ind., May 9, 1872. He graduated from Purdue University in 1894, and entered railway service the same year on the Vandalia. He went to the Illinois Central in 1896, and has served that road continuously in the positions of assistant engineer in maintenance and construction, roadmaster on five different divisions, and assistant to chief engineer maintenance of way, which position he leaves to become assistant engineer maintenance of way of the three companies.

Daniel Willard, president of the Baltimore & Ohio, has been elected president of the American Railway Association, succeeding F. A. Delano. H. U. Mudge was elected vice-president, and I. G. Rawn, president of the Chicago, Indianapolis & Louisville, and C. R. Gray, vice-president of the St. Louis & San Francisco, were elected to the executive committee. The following delegates were appointed to the International Railway Congress to be held at Berne, Switzerland: Daniel Willard, W. F. Allen, Arthur Hale, J. F. Wallace, William Mahl, C. W. Bradley, W. J. Harahan and G. L. Connor.

J. C. Jameson.

J. Drinkwater, district roadmaster of the Temiskaming & Northern Ontario at Englehart, Ont., has been promoted to inspector of work and forces in the road department, with jurisdiction over all lines.

W. F. Plate, division roadmaster of the Gulf, Colorado & Santa Fe, at Temple, Tex., has resigned. Samuel Lincoln, division roadmaster at Conroe, Tex., has been transferred to Temple, succeeding Mr. Plate.

E. O. Faulkner, manager of the tie and timber department of the Atchison, Topeka & Santa Fe, has had his jurisdiction extended over the timber lands owned by the company. George E. Rex, who has served as Mr. Faulkner's assistant, has been appointed manager of tie treating plants.

R. N. Begien, assistant to the chief engineer of the Baltimore & Ohio, with office at Baltimore, Md., was educated at the engineering school of Harvard University and was a member of the class of 1897. Mr. Begien was a member of the Nicaragua Canal Commission, in Central America, for three and a half years, resigning that position to go to South America to become a railway engineer in Ecuador. The following year he returned to the United States and took a position in the engineering department of the District of Columbia. He was appointed assistant engineer of the Baltimore & Ohio in August, 1902, at Somerset, Pa., and was made division engineer of the Philadelphia division in June, 1908, which position he held at the time of his recent appointment as assistant to the chief engineer.

In Railway Supply Circles

The latest concern to open a local office in the Chicago branch is the Indianapolis Switch and Frog Company, of Springfield, Ohio. It now occupies Suite 1528-29 McCormick building, with J. C. Jameson in charge as resident manager.

Mr. Jameson is admirably equipped to handle this position, as he has had many years' experience in the railroad field. He is fully informed on all the details of the business and well acquainted with conditions. He is genial, pleasant and has an army of friends. He is a welcome addition to the hustling body of resident managers of outside railway supply houses now making Chicago the center of their activities.

The company, in addition to its regular high-grade track equipment, has added to its line a new solid manganese frog, some of the features of which are that it connects up to full length rails and is "easier" protected.

Mr. George Marloff is western agent for the Lutz-Lockwood Mfg. Co., with office in room 1440 Monadnock block, Chicago.

Geo. Morloff.

This concern manufactures the well-known "Gordon" primary battery for use in connection with the operation of electric signals and highway crossing bells. Many thousands of these have been in succcssful operation on a number of railroads in this country for a period of twelve years, and are said to be giving excellent service. This concern also manufactures magnetos for automobiles and motor boats which they claim to be the most reliable and up-to-date device of its kind on the market.

W. H. Gardner, Jr., superintendent of roadway of the Gulf & Ship Island, has been appointed chief engineer, his former position having been abolished.

J. G. Hartley has been appointed supervisor on Division No. 6 of the Pennsylvania Railroad, with offices at Williamsport, Pa., succeeding G. H. B. English, promoted.

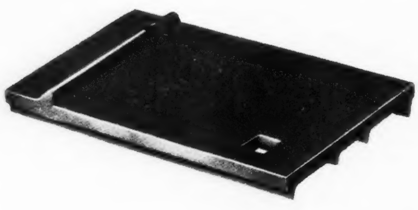
W. H. Williams, master mechanic of the Buffalo, Rochester & Pittsburgh, at East Salamanca, N. Y., has been appointed master mechanic of the Middle and Pittsburgh divisions, with office at Du Bois, Pa., and Harry Sneck has been appointed master mechanic of the Buffalo and Rochester divisions, with office at East Salamanca.

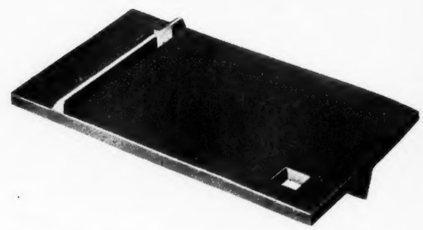
M. V. Hynes, division engineer of the Cincinnati, Hamilton & Dayton at Indianapolis, Ind., has been appointed acting engineer maintenance of way, with office at Cincinnati, Ohio, succeeding J. Tuthill, assigned to other duties.

ROLLED STEEL SHOULDER

TIE PLATES

ROLLED FROM NEW STEEL





STANDARD SPIKES

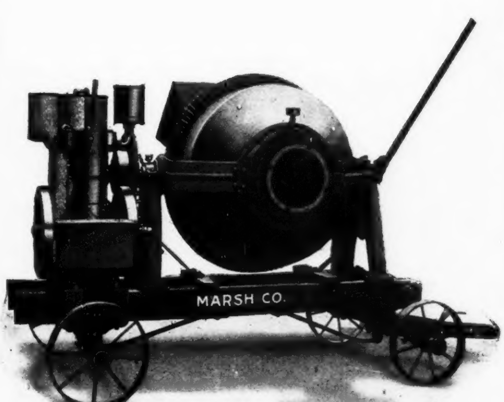
THE HART STEEL COMPANY

ELYRIA, OHIO

Plates and Spikes made by The Elyria Iron and Steel Co.

Our New Catalog
No. 4
Shows 17 Styles of
Tie Plates

Alphabetical Index to Advertisers


MARSH CO.

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